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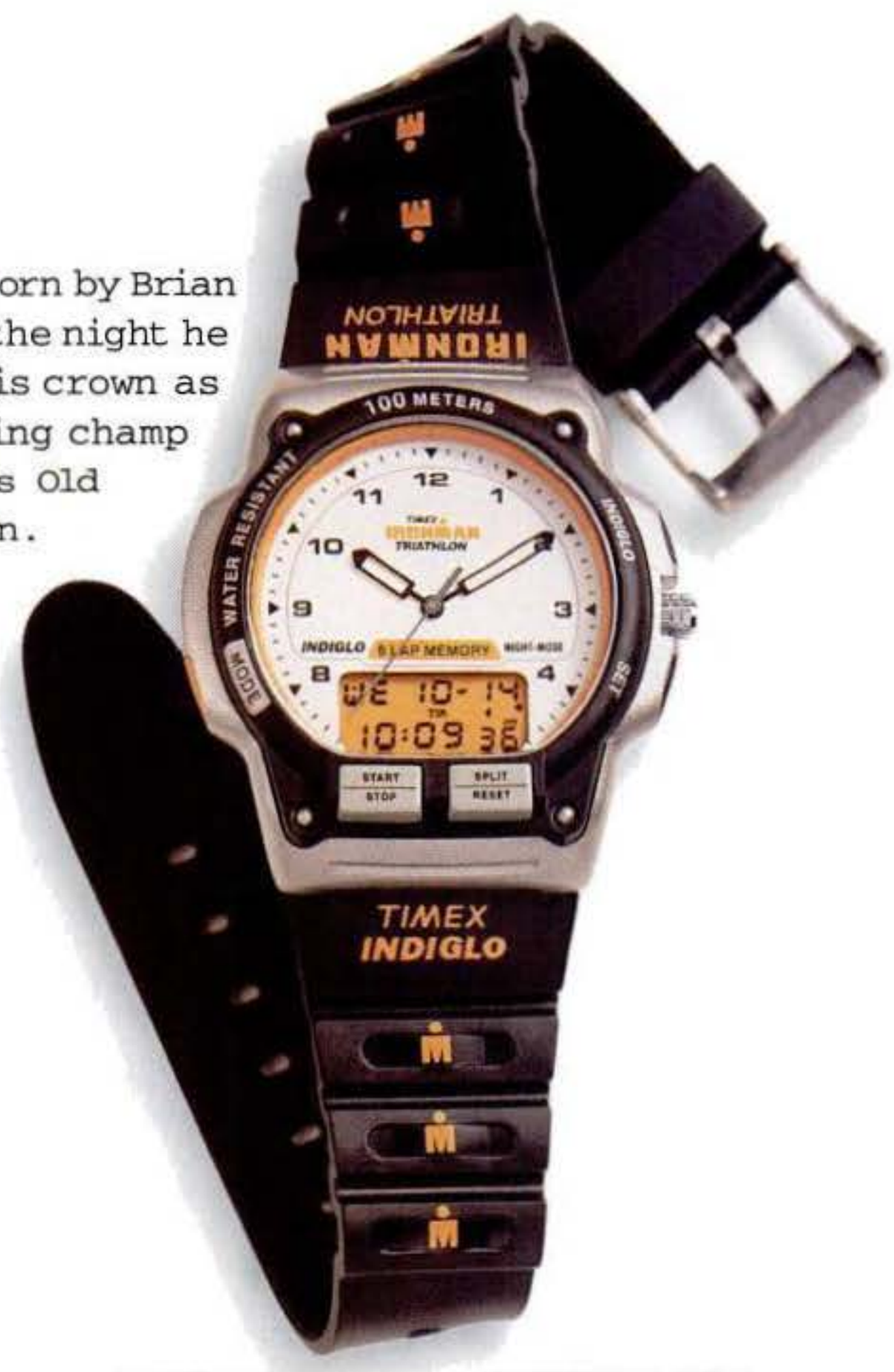
Jersey worn by Bronko Nagurski in 1943 when, after a 6 year retirement, he returned to play three positions for the Chicago Bears, and lead them to an NFL Championship.

Watch worn by Brian McDermott the night he regained his crown as arm-wrestling champ at Michael's Old Town Tavern.



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The new Ironman Triathlon analog/digital combo

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THE WHAT'S NEW MAGAZINE

Popular Science

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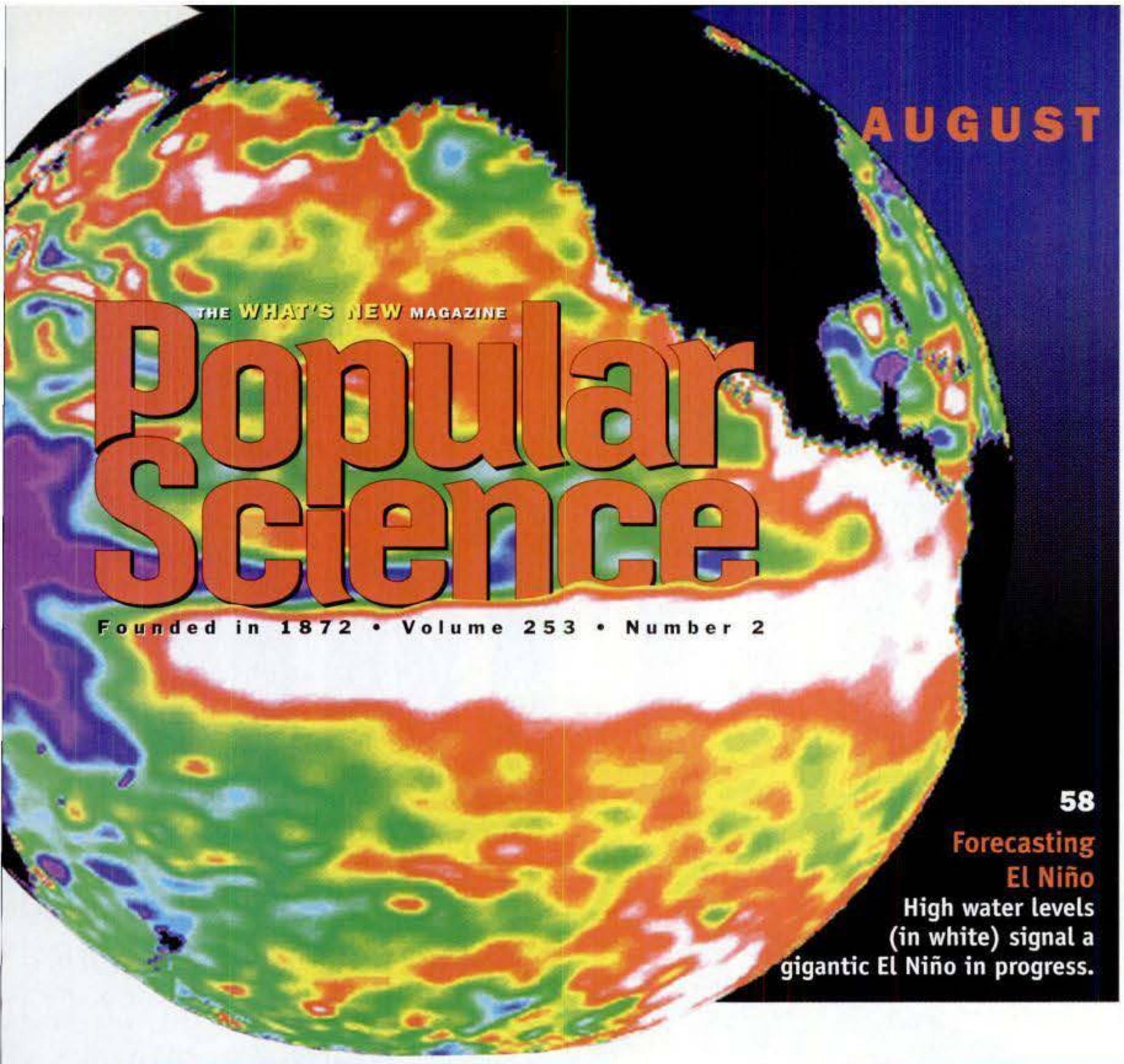

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Forecasting El Niño
High water levels (in white) signal a gigantic El Niño in progress.

COVER ART
TOM WHITE
Inset: (E-mail phone)
JOHN B. CARNETT

DEPARTMENTS

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Cellphone-GPS combo; scalpel that seals as it cuts; freezing home movies into digital stills.

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HOME TECHNOLOGY

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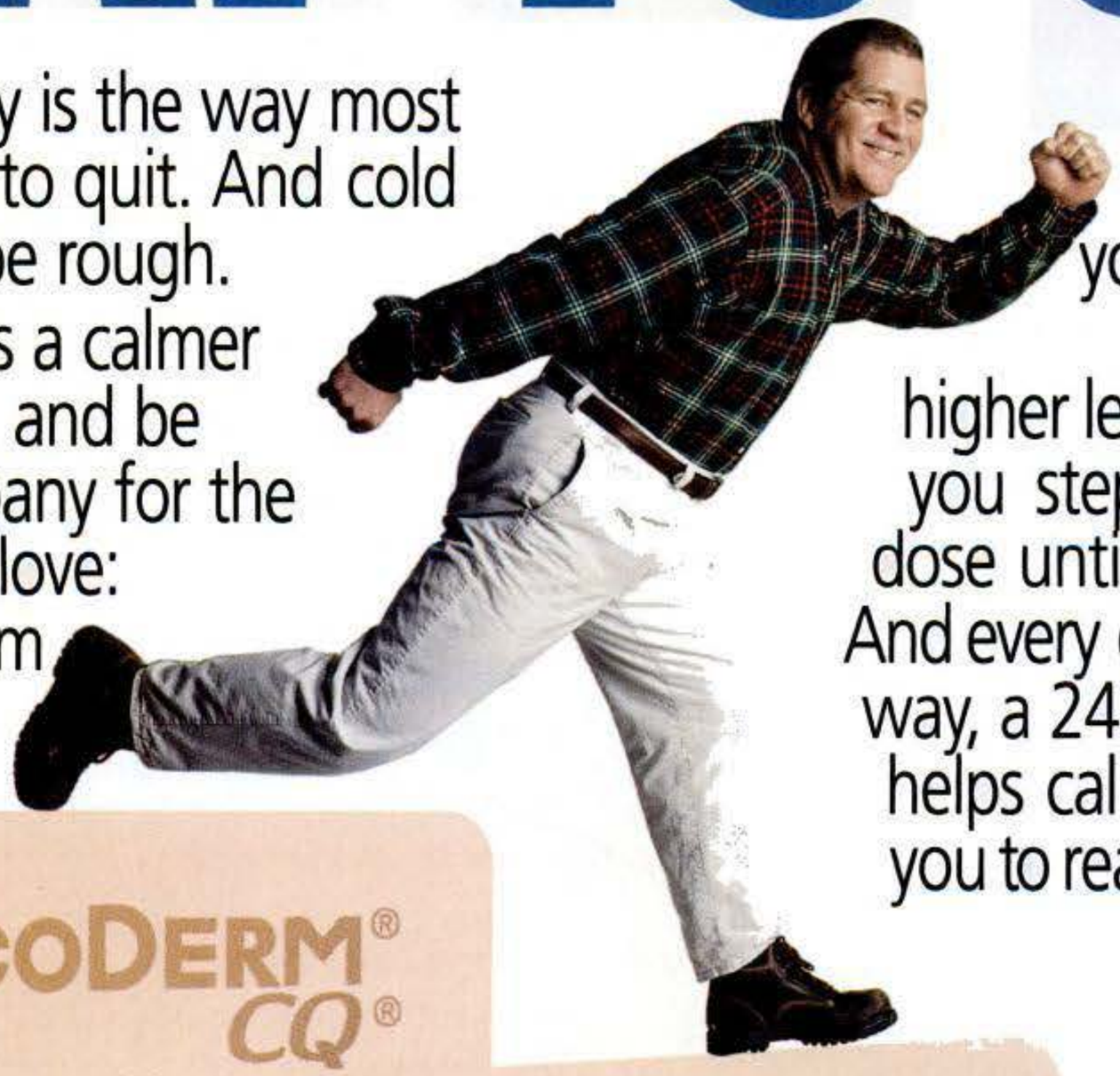
A CALMER WAY TO QUIT.

Cold turkey is the way most smokers try to quit. And cold turkey can be rough.

But there is a calmer way to quit, and be better company for the people you love: the NicoDerm CQ way.



You're most vulnerable to nicotine cravings when you first start to quit. So CQ starts you off with a higher level of medicine.* Gradually you step down your dose until you're free. And every day along the way, a 24-hour stream of medicine helps calm the cravings that tempt you to reach for that first cigarette.**

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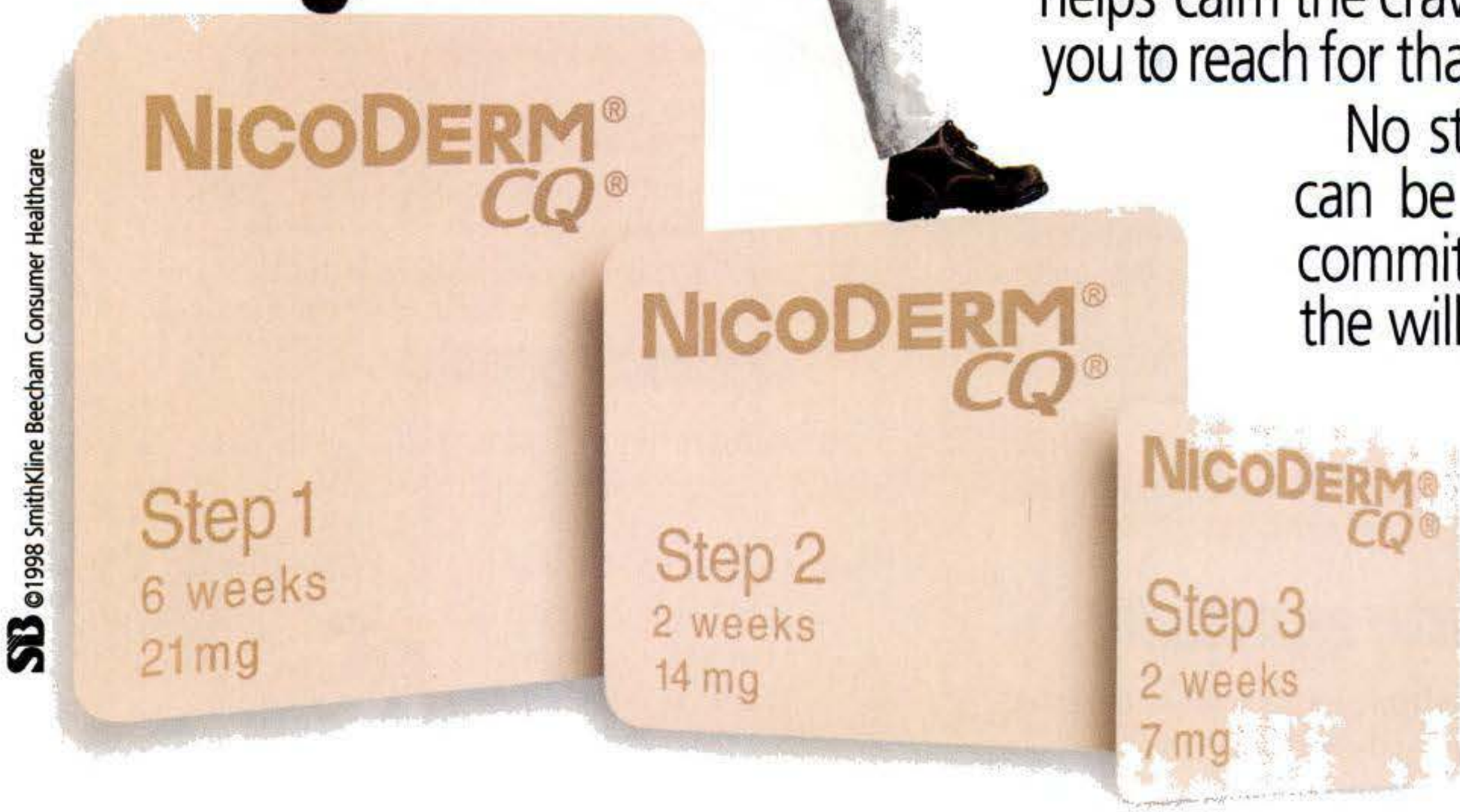
No stop-smoking aid can be a substitute for commitment. But once the will is there, CQ's a powerful help.



Success improves when used as directed in users guide.

*Light smokers start at Step 2.

**If you wear it for 24 hours.

Quitting is difficult.
Individual results may vary.

SmithKline Beecham makes an annual grant to the American Cancer Society to support its cancer fighting mission.

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The power to calm. The power to comfort. The power to help you quit.

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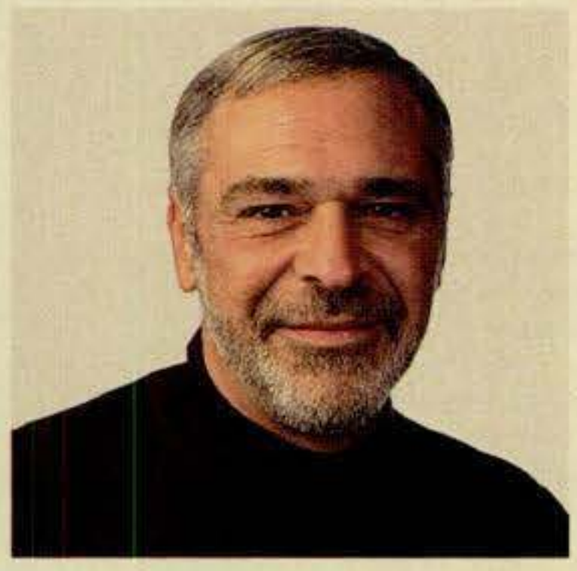
FROM THE EDITOR-IN-CHIEF



Reaching Toward Closure

ON THE BLACK GRANITE Vietnam Veterans Memorial in Washington, D.C., more than 2,000 of the 58,214 names have a telltale cross inscribed alongside. This denotes a soldier listed as missing in action. Now, more than 23 years after the war's last official casualty was recorded, an advanced technology is helping us confirm the identity and, in some cases, learn more about the fate of some of these soldiers. Recently, the remains of a pilot were exhumed from the Tomb of the Unknowns, to undergo mitochondrial DNA analysis, one of the most powerful tools ever developed for forensic research. In an exclusive story, retired Air Force Col. Ralph Wetterhahn reports on a task force he accompanied, beginning in 1995, to learn the fate of soldiers involved in the rescue of the *SS Mayaguez*, a merchant ship help hostage in Cambodia. Many consider this the war's last official battle. Indeed, the name of Lt. Richard Vandegeer, whose remains were retrieved as part of that mission, is the last one listed on the chronologically arranged Memorial. And now his family, and those of other casualties, can come to closure.—*Fred Abatemarco*

Solar Power

I FOUND YOUR report about the new practicality of solar power ["Finally Affordable?" Home Technology Newsfront, June] intriguing, but I'd like some clarification. Do 250-watt panels produce 250 watts of electricity per hour? If so, approximately how many panels will I need to reduce my monthly utility bill to nothing? Do these panels work only in certain climate areas?

Peter.Tunkhannock@msn.com

First, the easy part: 250-watt panels do indeed produce 250 watt-hours of electricity. But determining how many panels will reduce your utility bill to nothing is a bit more difficult, because such factors as your home's size, location, and amenities come into play. The average American home receives the equivalent of 4 hours of direct sunlight daily, so each panel would produce about 1 kilowatt-hour of power each day. The average American family uses about 6 kilowatt-hours of electricity every day, so six 250-watt panels would satisfy these energy needs. Of course, Arizona receives more direct sunlight than Seattle on average, so fewer panels would produce the same amount of power. Likewise, energy needs vary by geographic area and by season.

ABS Challenged

WHILE "The ABCs of ABS" [June] concluded that antilock braking systems work as advertised, I'm still not convinced they are worth the money. The amount of time I drive on ice at 40 mph with a distance of 250 feet to both brake and maneuver—one situation in which, you report, antilock brakes really help—amounts to a negligible percentage of my total driving time. If the auto companies would make more reliable parts and remind people to slow down under adverse conditions, safety would improve without consumers having to pay for expensive ABS systems.

James Benson
Chicago, Ill.

Beyond the Outer Limits

IN "COMPUTING'S Outer Limits" [March], you report that Sun Microsystems might be working on a chip, due by the year 2000, that will have 30 million to 40 million transistors. But Hewlett-Packard engineers will have the PA-8500 processor available in 1999 with 145 million transistors. It will power servers and workstations from Hewlett-Packard.

Bob Noler, VLSI Tech. Center
Hewlett-Packard Co.,
Fort Collins, Colo.

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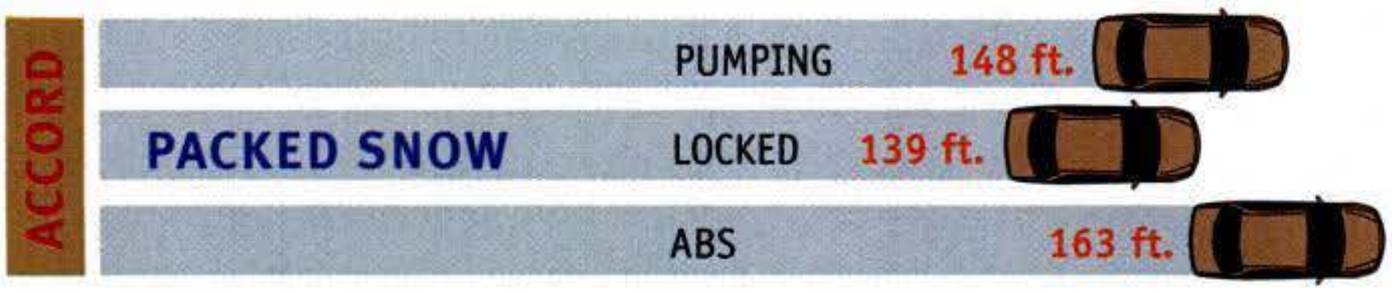
ABS Revisited

IN SOME EDITIONS, the chart accompanying our story about antilock braking systems ["The ABCs of ABS," June] was unclear. The stopping distances for the Honda Accord are shown here.



Where's the Beef?

I AM CONCERNED about an issue that wasn't addressed in "Beefing Up Food Safety" [June]: What about the health threat from radiation-resistant organisms?

Kay Hulbert
Columbus, Ohio

It is possible that irradiation will permit radiation-resistant strains of common food-borne pathogens to flourish on foods. But, according to FDA food scientist George Pauli, the risk of contamination is relatively low. Still, as the article notes, it's always wise for consumers to follow all safe-handling instructions on a meat package's label, regardless of whether or not the meat has been irradiated.

IT'S ABOUT time we have a choice to buy irradiated meats!

George Lumis
Harrisburg, Pa.

Record Your Own CDs

I READ "Finally! Recordable CDs" [June], with great interest. For all the story's thoroughness, however, it did not cover the ability to make audio discs on a computer. This is a fairly common practice, especially because the street price for compact disc recorders is approximately $250 and blank recordable discs sell for $1.50 apiece.

Stephan Vogt
svogt@mindspring.com

You're absolutely right: Computer CD-R drives can be used to copy music compact discs using the far-less-costly CD-R data discs. But neither the CD-R drive makers nor the music industry encourages this practice, since it's not the intended purpose of these drives, and royalties are not paid to the recording artists. Legally, this is a gray area, but if you make copies only for personal use, it's unlikely you'll run into trouble. As the prices of easier-to-use CD-Audio recorders and media come down, however, the incentives for copying discs using your computer will diminish.

IN YOUR STORY, you say that DVD-RAM drives available for PCs this summer will be priced at more than $1,000. But Creative Labs has just released its DVD-RAM system for only $499. This system reads everything, and it writes CD-Recordable disks at 9X. More information is available at *www.soundblaster.com.*

nmrcpah@gwgate.bas.ncsu.edu

Correction: Shown below is BMW's M5 high-performance sedan based on the 5 Series models ["Huge Horsepower," What's New, June].

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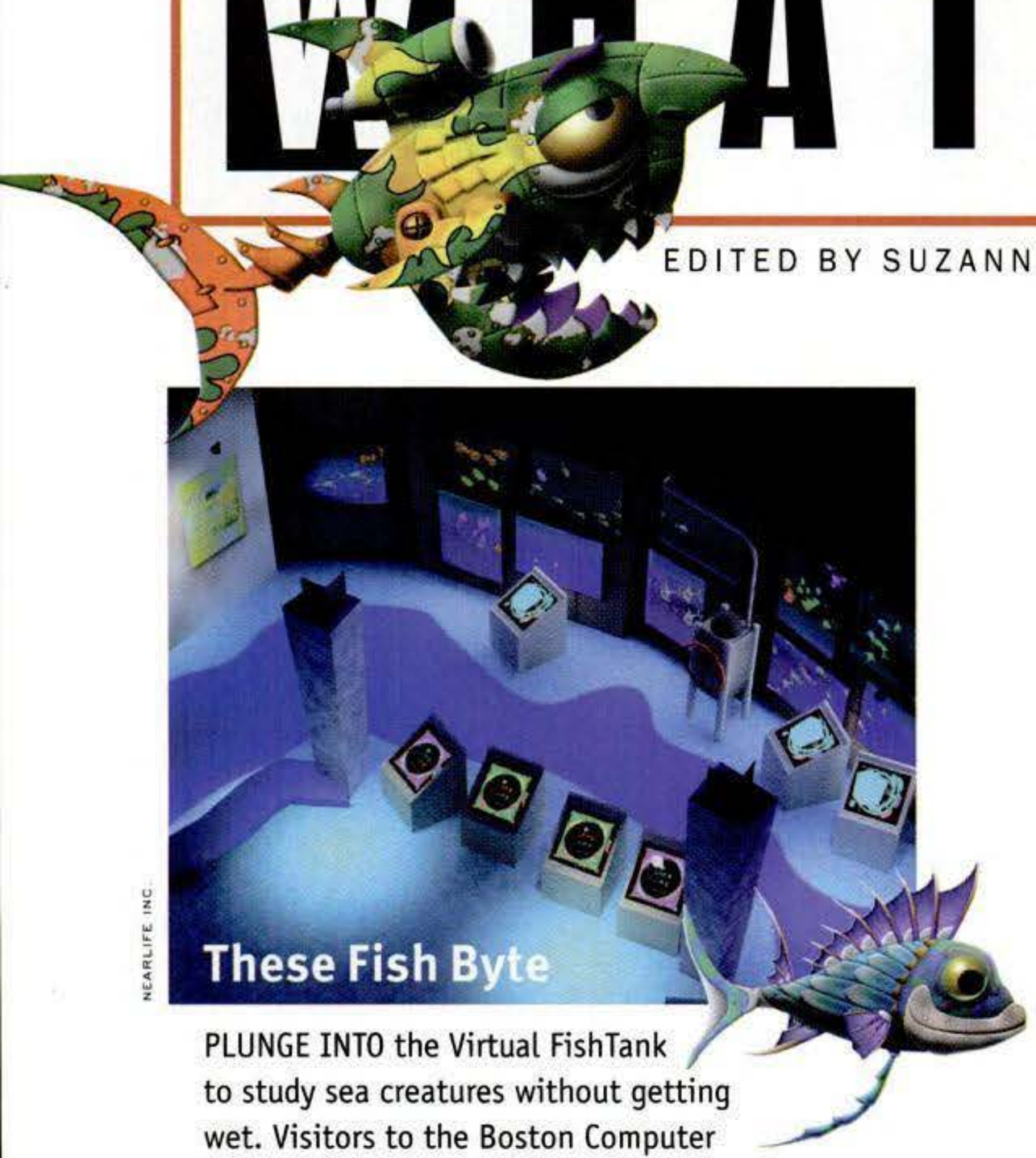


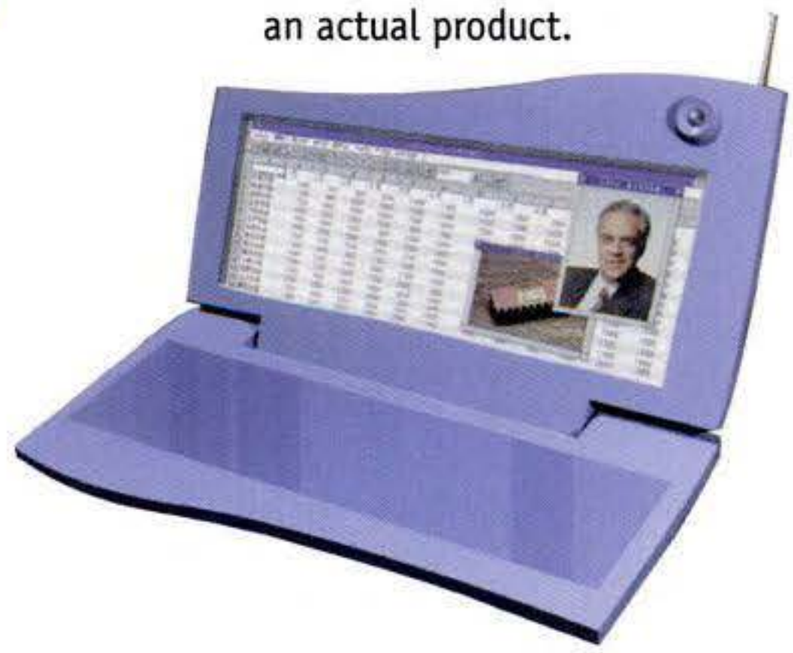
These Fish Byte

NEARLIFE INC.

PLUNGE INTO the Virtual FishTank to study sea creatures without getting wet. Visitors to the Boston Computer Museum's aquatic exhibit can design their own virtual fish, feed them, and launch them into a 400-foot tank to see how the behaviors they've programmed affect the fishes' survival chances. The "tank" uses 3-D computer graphics that are projected onto 12 large screens. The Computer Museum, 300 Congress St., Boston MA 02210.

Palmtop Videoconferencing

THE PALMTOP PC of the future will include a built-in camera for wireless transmission of video and still images, at least in the concept PC developed by Sharp's engineers. Sharp currently has no plans to turn the laboratory curiosity into an actual product.



Finer, Faster Focus

MINOLTA'S MAXXUM Xtsi SLR camera is the first with three charge-coupled devices for a faster, more accurate autofocus system. The CCDs overlap vertically and horizontally, creating a cross-hair focal point in the center with focal boxes on both sides. Price: $500. Minolta Corp., 101 Williams Dr., Ramsey NJ 07446.

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Race Without Rules

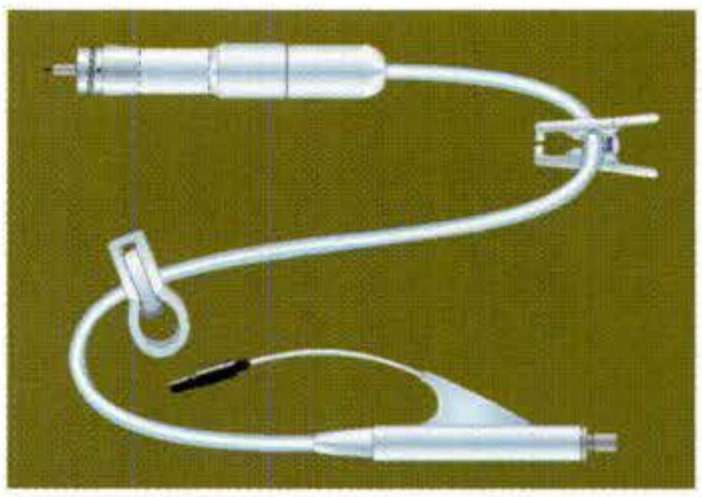
NO RULES govern the size or type of boat that can be entered in The Race, an around-the-world drag contest scheduled for 2000, and competitors are already lining up. Pete Goss's entry, the Goss Challenger, will be the biggest two-mast catamaran in the world, measuring 115 by 60 feet. The craft can maintain speeds near its 40-knot top speed; with an advanced fiber-optic control system, it needs only a five-person crew. *www.petegoss.com*

Twist and Steer

TO CHANGE gears while driving the Hyundai Euro-1, merely twist the grip on the steering wheel. Designed at Hyundai's Frankfurt R&D center, the concept car packs a 380-horsepower turbocharged intercooled 2.0-liter four-cylinder engine. The open cockpit features electrically adjustable pedals and steering column, plus a windshield that can be raised or lowered hydraulically.

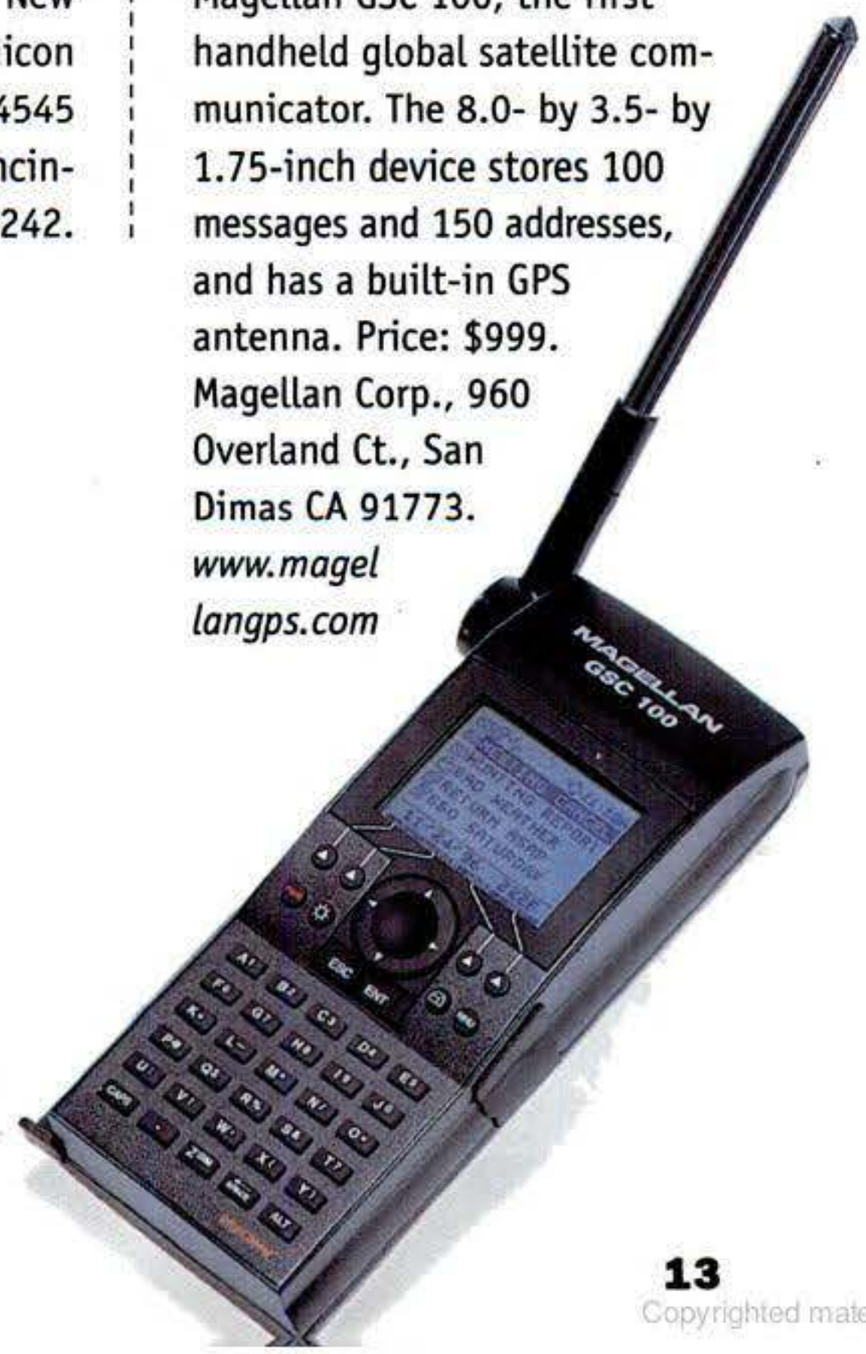
It Slices, It Coagulates

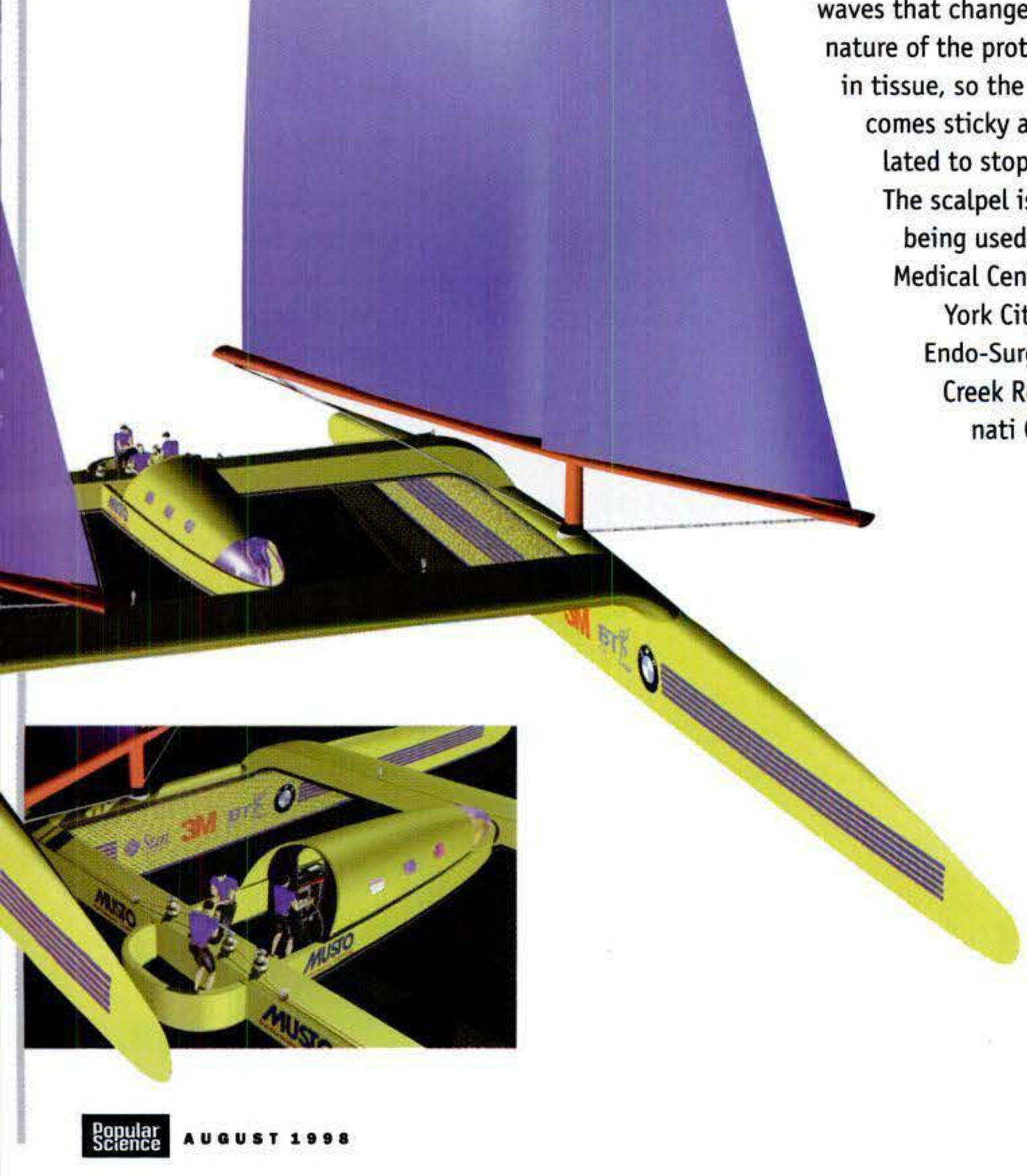
THE ULTRACISION scalpel seals as it makes incisions. Vibrating at 55,000 times per second, the blade generates ultrasound waves that change the nature of the proteins in tissue, so the tissue becomes sticky and coagulated to stop bleeding. The scalpel is currently being used at Cornell Medical Center in New York City. Ethicon Endo-Surgery, 4545 Creek Rd., Cincinnati OH 45242.



The Whole World in Your Hands

SEND AND RECEIVE e-mail anywhere in the world with the Magellan GSC 100, the first handheld global satellite communicator. The 8.0- by 3.5- by 1.75-inch device stores 100 messages and 150 addresses, and has a built-in GPS antenna. Price: $999. Magellan Corp., 960 Overland Ct., San Dimas CA 91773. *www.magellangps.com*





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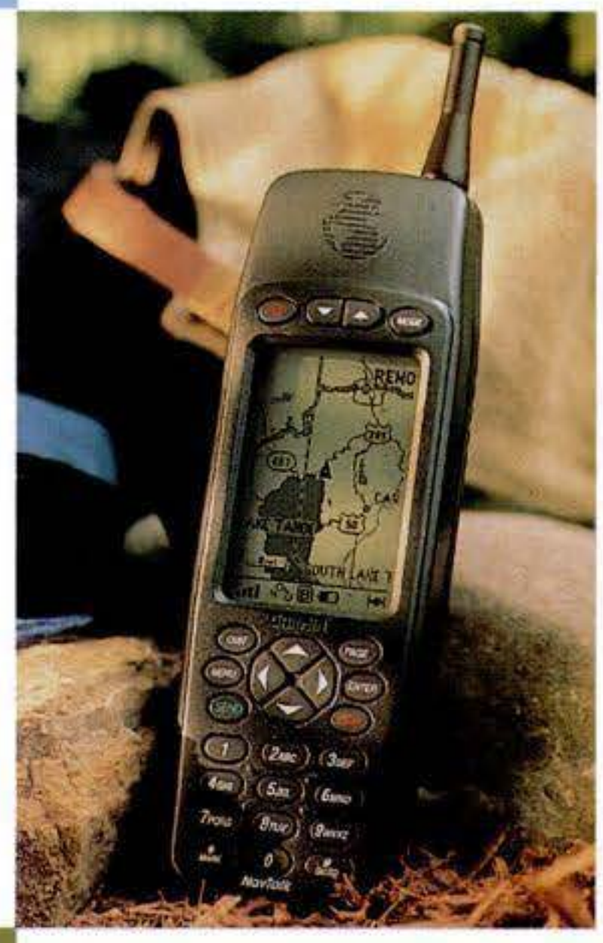
A Hedge Against Deflation

WHEN YOU'RE TIRED from pedaling, the last thing you want to do is pump up a flat tire. You don't have to with the Ultraflate carbon dioxide inflator. The pocket-size device, which fits any bike-tire valve, uses a CO_2 cartridge to inflate the tire within seconds. Price: $18. Innovations in Cycling, 2700 E. Bilby Rd., Bldg. C, Tucson AZ 85706.

Freeze Frame

WITH THE FLICK OF A BUTTON, transform home movies into digital still photos with Sony's MaviCap Floppy Disk Recorder. The MaviCap, which fits all analog camcorders, stores images on a 3.5-inch floppy —allowing you to e-mail, print, or simply file them away. Video inputs and outputs project images on a TV screen, and a slideshow mode turns the MaviCap into an instant projector. Two models are available: the MVC-FDR1 ($349); and the MVC-FDR3, equipped with a 2.5-inch color LCD (shown; $599). *www.sony.com*



Cellphone with Navigation

THE NAVTALK from Garmin marries a mobile cellphone with a GPS receiver—just the thing if you need help and aren't sure of your location. If the person you're calling is also using a NavTalk, the display shows you exactly where he is as well. The mapping software covers the United States, Canada, and South America and shows major transportation arteries —the phone lets you call for local directions. Garmin International, 1200 E. 151st St., Olathe KS 66062. *www.garmin.com*

Initial Invasion

KOREAN carmaker Daewoo Motors is launching cars in the United States for the first time this fall. The trio includes the midsize Leganza, the compact Nubria, and the subcompact Lanos (shown). The Lanos, which has a 99.2-inch wheelbase, is powered by a 1.6-liter 16-valve four-cylinder. On sale in 14 cities, the cars will be sold through a new chain of company-owned stores. Prices not available.

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HEAR WHY THE BOSE® WAVE® RADIO WAS NAMED A "BEST NEW PRODUCT OF 1994" BY *BUSINESS WEEK*.

Tabletop radios are popular for their convenience and small size. But their sound quality leaves much to be desired. No one really expects high-fidelity sound from a radio. Until now.

Set six AM and six FM stations.

Easily connect your CD player, cassette player, TV, or VCR.

Just as a flute strengthens a breath of air to fill an entire concert hall, the waveguide produces room-filling sound from a small enclosure. This technology and performance is available in no other radio.

You'll touch a button and hear your favorite music come alive in rich stereo sound. You'll hear every note the way it's *meant* to be heard. The Wave radio measures just 4⅛"H × 14"W × 8¼"D and fits almost anywhere. So you can listen in your bedroom, living room, kitchen, or any room. And with your choice of imperial white or graphite gray, the Wave radio not only fits in any room, it fits any decor.

CALL NOW AND MAKE SIX INTEREST-FREE PAYMENTS.

The Wave radio is available for $349 directly from Bose, the most respected name in sound. So call 1-800-845-BOSE, ext. R8423, to learn more about our in-home trial and 100% satisfaction guarantee. When you call, be sure to ask about our six-month installment payment plan.

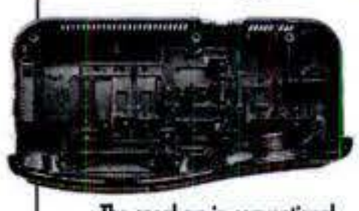
HEAR THE RADIO THAT WOKE UP AN ENTIRE INDUSTRY.

Bose presents the Wave radio. It's the one radio acclaimed by leading audio critics. Because it's the one radio that delivers big, rich, lifelike stereo sound *plus* a small, convenient size.

Wired magazine said it has a "clean, sweet sound that will have your friends wondering where you've hidden your fancy speakers." But you have to hear the Wave radio for yourself to believe it.

THE BEST-SOUNDING RADIO YOU CAN BUY.

We think the Wave radio is the best-sounding radio you can buy. And audio critics agree.



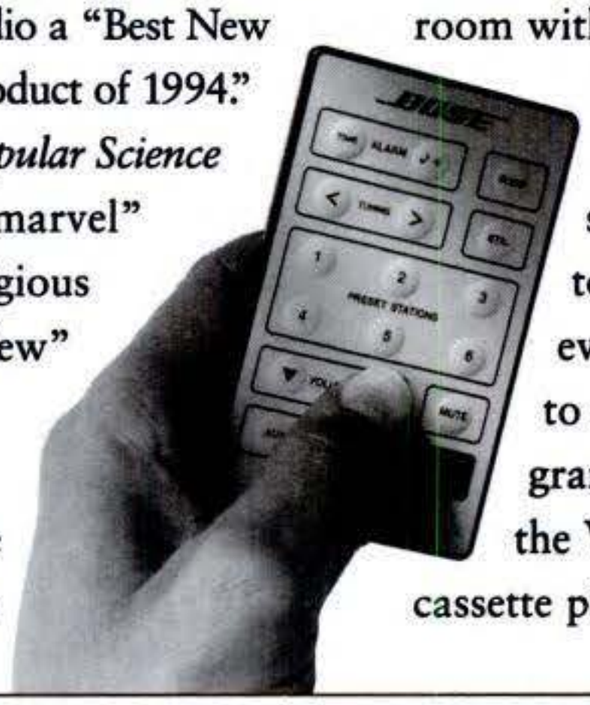
The speakers in conventional radios cannot produce lifelike bass, which is essential for great sound.

Only the Wave radio with acoustic waveguide speaker technology produces high-quality sound with full, rich bass.

Radio World called the sound "simply amazing...a genuine breakthrough in improved sound quality." *Business Week* named the Wave radio a "Best New Product of 1994." *Popular Science* called it "a sonic marvel" and gave it a prestigious "Best of What's New" award. The key is our patented acoustic waveguide speaker technology.

REMOTE-CONTROLLED CONVENIENCE.

Operate the radio from across the room with the credit card-sized remote control. Set six AM and six FM stations, and switch between them at the touch of a button. You can even bring great Bose sound to recorded music, TV programs, or movies by connecting the Wave radio to your CD or cassette player, TV, or VCR.



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Our six-month installment payment plan is available on telephone orders only.

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Mail to: Bose® Corporation, Dept. CDD-R8423, The Mountain, Framingham, MA 01701-9168.

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©1998 Bose Corporation. Covered by patent rights issued and/or pending. Installment payment plan not to be combined with any other offer and available on credit card orders only. Price does not include $15 shipping and handling and applicable sales tax. Price and/or payment plan subject to change without notice. Frank Beacham, *Radio World*, 12/93. *Wired*, 6/94.

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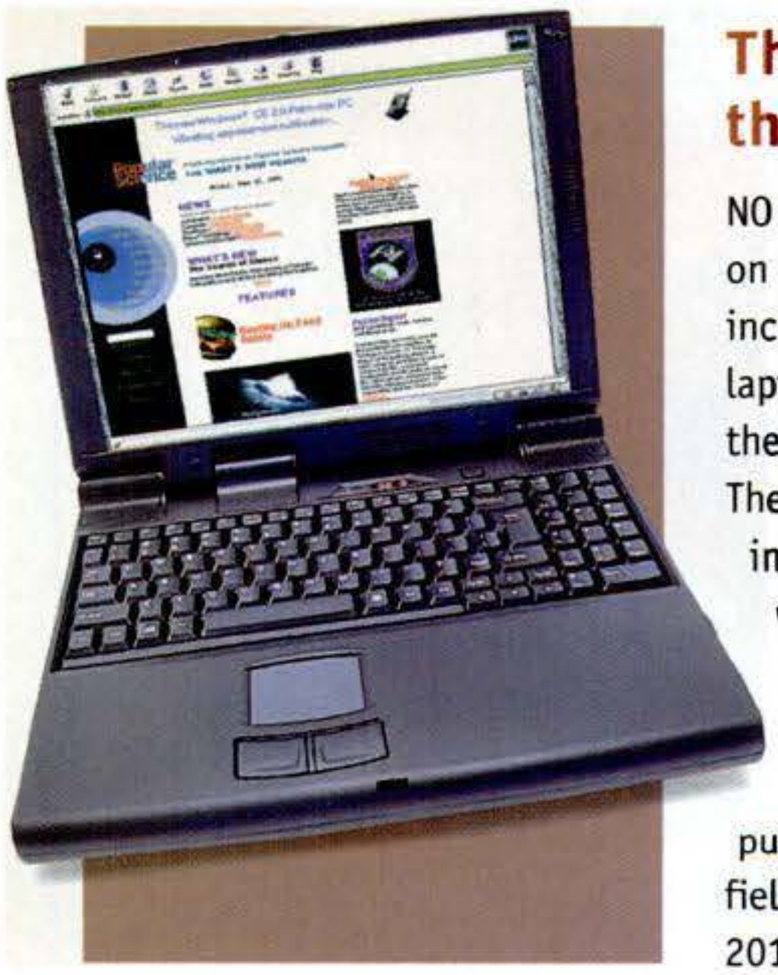
From Zero to Screaming

THE MR. FREEZE roller coaster doesn't build speed via the usual initial lift hill; rather, the power from a series of linear induction motors propels the cars forward instantly. Metal fins projecting from the cars run through motors installed on the track. Like magnets, the fins and motors repel each other to create forward motion. How fast? Try 70 miles per hour in 3.8 seconds. Six Flags Over Texas, Box 90191, Arlington TX 76004.



The Size Is the Prize

NO NEED TO squint to see text on the Metrobook DT. Its 15.1-inch XGA display, a first for laptops, is the same size as the average desktop monitor. The DT can't match desktops in processing prowess, but with a 266MHz Pentium MMX processor, it's got plenty of power. Price: $4,495. Metrobook Computer Corp., 14240-K Sullyfield Circle, Chantilly VA 20151. *www.metrobook.com*

Never Before Heard Bird

RESEARCHERS at the Federal University of Parna, in Parna, Brazil, have discovered a previously unknown bird species, the lowland tapaculo. While the black-and-white bird resembles other birds of the *Scytalopus* genus, researchers recognized its newness by its unique song. Upon further study, researchers identified 11 unique features that qualify it as a rare bird, indeed.

TOM GRANDO JR.

Clip Notes

MOST RIDING MOWERS toss clippings into bins, located behind the seat, that make the mower awkward to pilot. Now MTD's ultracompact Bug has an internal catcher that stores as much as 2.5 bushels of clippings. A monitor tells you when the catcher is full. The Bug also mulches. It's powered by an 8.5-horsepower engine and features a pedal-operated automotive-like drive system with infinite speed control—but not, unfortunately, infinite speed. Price: $999. Yard-Man, MTD Products, Box 368022, Cleveland OH 44136.

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You have 20 minutes to make an appointment at an address you've never heard of.

We'll take You there.

Panic's about to set in. Lucky for you, the GARMIN StreetPilot can get you out of that jam and guide you where you want to go. GPS satellites pinpoint your location on an electronic map. Insert a data card and access detailed street information and a huge city database. But don't let the technology scare you. You'll find the StreetPilot easy to use right out of the box.

FIND ***an address.***

Enter an address and the StreetPilot takes you there. It shows that destination on the map, your position on the map, and directions between the two.

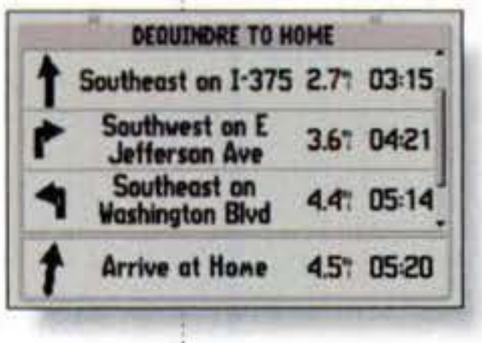
FIND ***nearby services.***

Push the FIND button and follow the prompts to view the nearest businesses, attractions, shopping or food.

When you see what you like, drive to it using StreetPilot's directions.

FIND ***your way home.***

Best of all, with StreetPilot you'll never be lost. It shows exactly where you are on the map. You can store your favorite locations so you can always get back.



StreetPilot takes navigation technology to the streets. It's around town peace-of-mind that's portable, affordable and easy to use. Call 888-4-GARMIN, to find your nearest GARMIN dealer. It just might be the last time you ask for directions.

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Fighting Whiplash

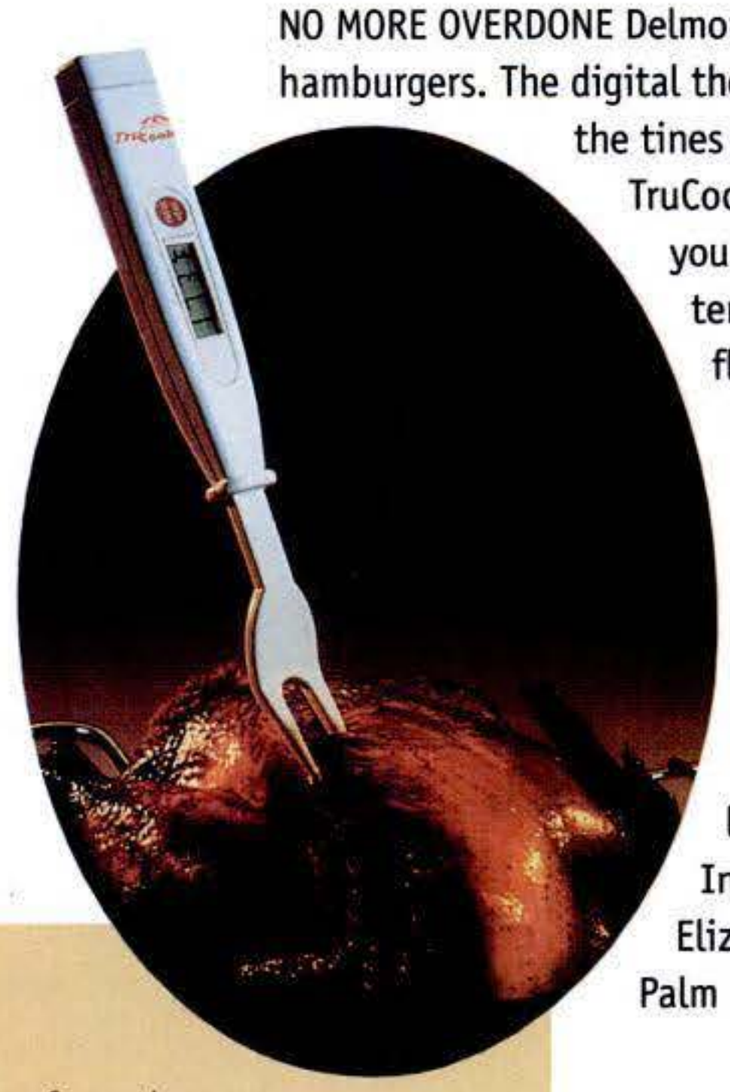
VOLVO'S S80 SEDAN sports two new features designed to further protect occupants during a collision. One is an inflatable curtain, which deploys in about 25 milliseconds to protect the head and shoulders of both front and rear passengers from side impacts. In conjunction, side-impact airbags protect the rest of the body. The second is a new seat and headrest that move backward with the force produced by a rear end collision to reduce the incidence of whiplash. Price: $38,900. *www.volvocars.com*

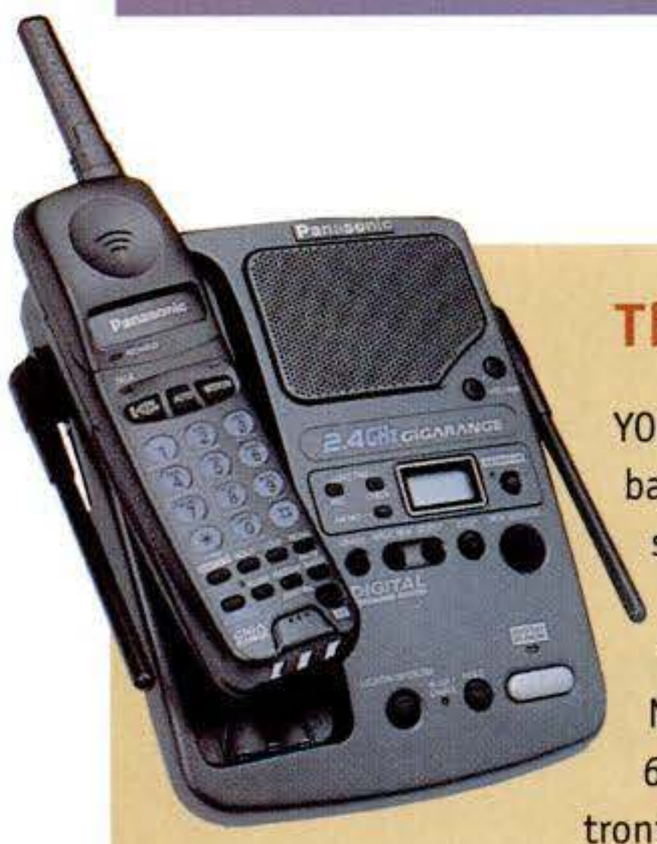
What in Blue Blazes?

THERE'S NO MISTAKING the iMac for any other home computer—assuming you recognize it is a computer. The iMac ($1,299) sports a translucent blue look, and there's plenty of power inside its one-piece suit. It runs on a 233MHz G3 processor and features a 15-inch screen, 32MB of memory, a 4GB hard drive, and a 24x CD-ROM drive. There's no floppy, however, and only a 33Kbps modem. *www.apple.com*

A Rare Thermometer

NO MORE OVERDONE Delmonicos or still-mooing hamburgers. The digital thermometer built into the tines of the Norcross TruCook ThermoFork lets you measure the meat's temperature while flipping the steaks. Model 1416 ($30) displays the temperature on its LCD; Model 1417 ($25) indicates doneness with a series of indicator lights. Norcross Industries, 1500A Elizabeth Ave., West Palm Beach FL 33401.





The Call of the Mile

YOU CAN wander more than a mile away from the base station of a Panasonic's GigaRange cordless telephone and still be able to place a call. The first cordless phone to operate in the 2.4-GHz band, the unit's range is nearly eight times as far as that of a 900MHz cordless, or approximately 7,700 feet. Nickel-metal-hydride batteries provide 14 days of standby and 6 hours talk time. Price: $200 to $300. Panasonic Consumer Electronics, One Panasonic Way, Secaucus NJ 07094. *www.panasonic.com*

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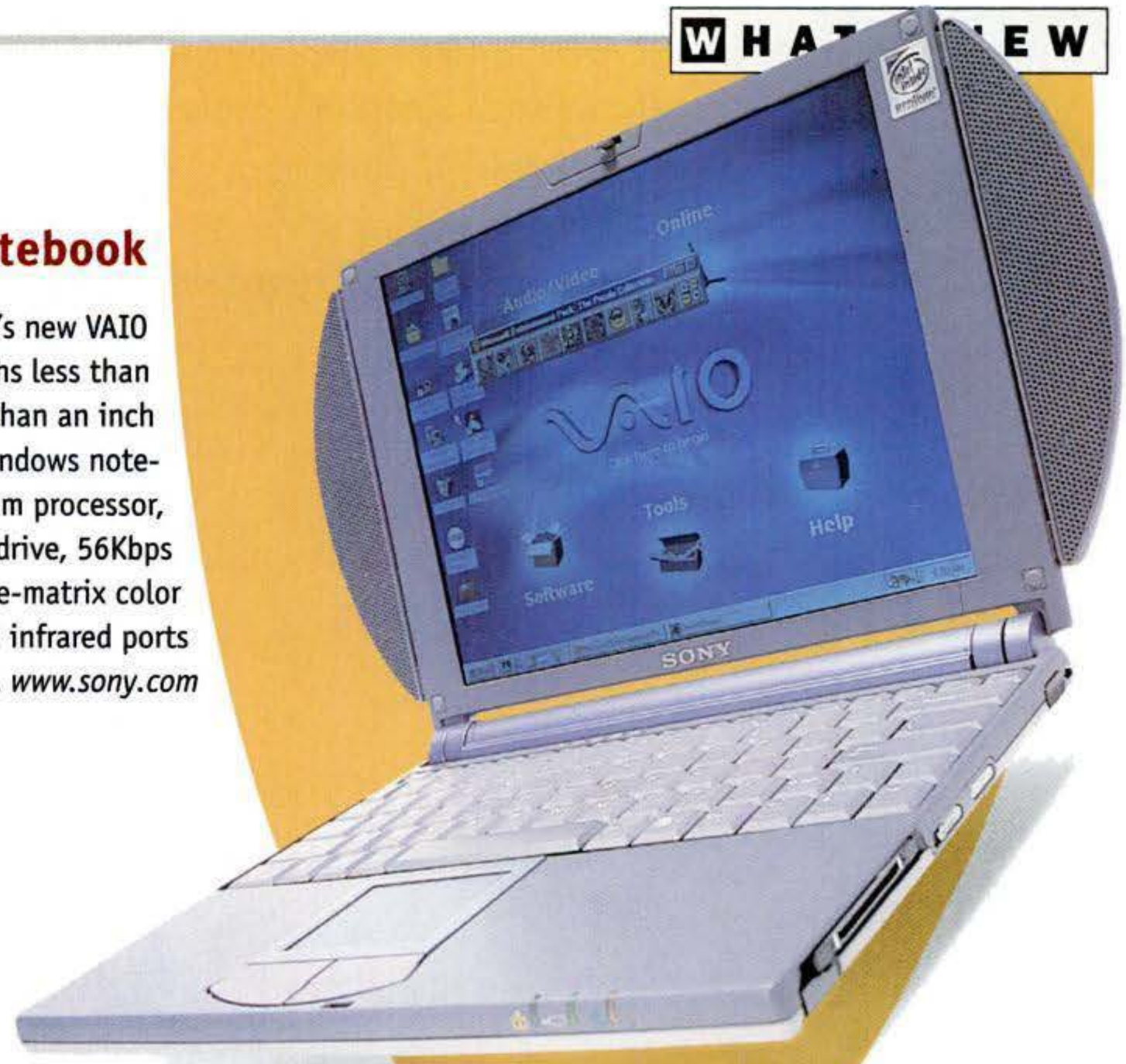
Cliff's Notebook

HERE'S THE SKINNY on Sony's new VAIO 505G Super Slim laptop: It weighs less than 3 pounds and measures less than an inch thick. Yet it's a full-function Windows notebook, with a 200MHz Pentium processor, 32MB of memory, 2.1GB hard drive, 56Kbps modem, and 10.4-inch active-matrix color LCD screen. It has USB and infrared ports as well. Price: $1,999. *www.sony.com*



Dialing Saves Dollars

TWO PANASONIC fax machines use the Internet to save cash on overseas faxes. Press IQ-Fax on the KX-FP250 or KX-FM260 to transmit via the Net to the FaxSav server closest to the destination. The fax is then sent along regular phone lines to the recipient's fax machine. You are billed for only overseas charges by FaxSav. Prices: $250 (KX-FP250), $280 (KX-FM260, hooks up to a computer for scanning and printing). Panasonic Consumer Electronics, One Panasonic Way, Secaucus NJ 07094. *www.panasonic.com*

Everything 3-D

SEGA IS introducing the next generation of video game systems this fall in Japan. Dreamcast will run on a 200MHz SH-4 RISC processor, 3-D graphics chip set, and 3-D audio chip set —a combination that outperforms most PCs. The Visual Memory System card, plugged into the game controller, can be programmed with special moves for fighting games. When removed, it's a portable game system. U.S. intro is expected in fall 1999. Price not yet set. *www.sega.com*

No Hydrogen Bomb

HYDROGEN made from sunlight and water is a potentially limitless fuel source. That's why the hydrogen-powered prototype two-seater that's hit the streets in Palm Desert, California, is so exciting. The cart uses a fuel cell that chemically generates electricity pollution-free from hydrogen and water. The cart has a range of 30 miles and can hit a top speed of 35 mph. Schatz Energy Research Center, Humbolt State University, Arcata CA 95521.

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The Everex Freestyle™ is a compact, lightweight, and highly functional Palm-size PC designed to provide today's mobile professional instant access to their most vital information. Powered by Microsoft's Windows® CE 2.0 operating system, the Everex Freestyle™ combines advanced PIM and productivity applications with seamless desktop data synchronization and mobile communication capabilities in a lightweight pocket-size form factor that fits in the palm of the hand.

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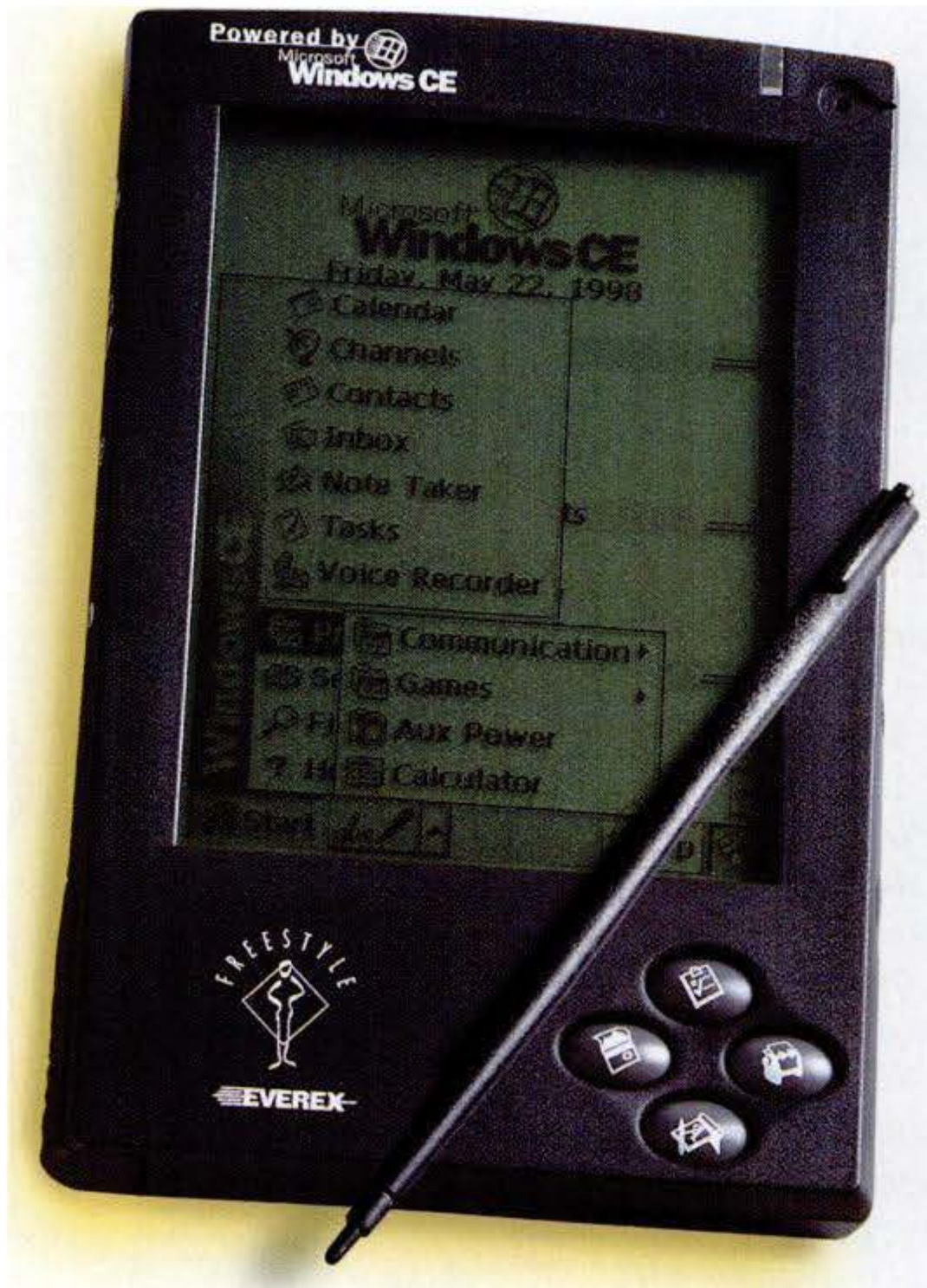

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EVEREX Workstations • Servers • Notebooks • Desktops • Palm-size PCs

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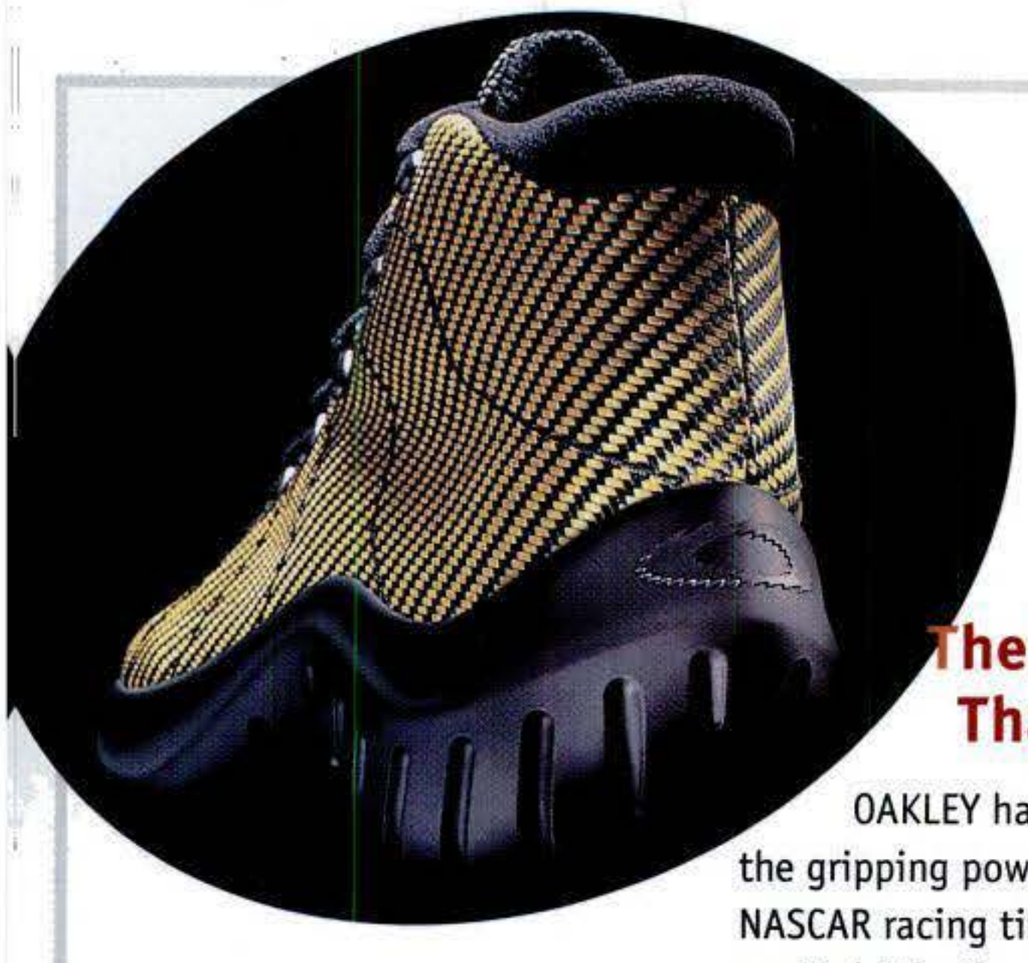
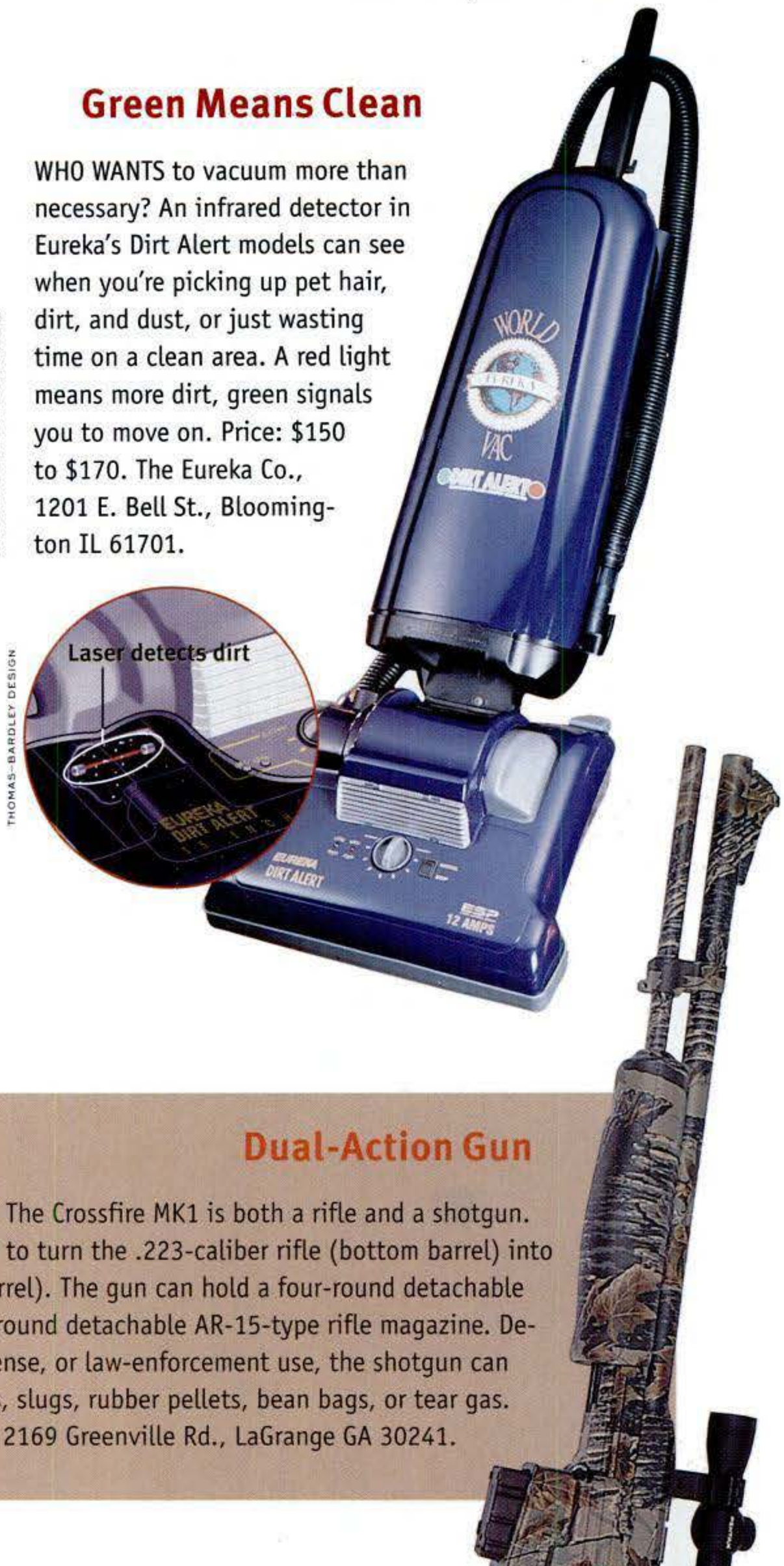


The Shoes That Grip

OAKLEY has taken the gripping power of NASCAR racing tires and applied it to its new multisport sneaker, called The Shoe. The bottom, or outsole, of The Shoe is made from rubber impregnated with Kevlar fibers, which provides grip regardless of tread pattern and wear. Other features include shoelaces that won't untie accidentally and an elaborate moisture wicking system. Price: $129. *www.oakley.com*

Green Means Clean

WHO WANTS to vacuum more than necessary? An infrared detector in Eureka's Dirt Alert models can see when you're picking up pet hair, dirt, and dust, or just wasting time on a clean area. A red light means more dirt, green signals you to move on. Price: $150 to $170. The Eureka Co., 1201 E. Bell St., Bloomington IL 61701.



THOMAS-BARDLEY DESIGN

Not a Sonata, but Close

HYUNDAI'S Avatar show car offers a glimpse of what we'll see in the next-generation Sonata to be introduced in the fall. They'll share a new transverse-mounted V6 engine. Suspension is double front wishbone —a departure from the standard strut-type. The concept car also has electronic traction control and four-channel ABS. But it's the stylish bar grill that tickles us.

Dual-Action Gun

TALK ABOUT MULTITASKING. The Crossfire MK1 is both a rifle and a shotgun. Flick a lever near the trigger to turn the .223-caliber rifle (bottom barrel) into a 12-gauge shotgun (top barrel). The gun can hold a four-round detachable shotgun magazine and five-round detachable AR-15-type rifle magazine. Designed for hunting, self-defense, or law-enforcement use, the shotgun can accommodate 00 buck shells, slugs, rubber pellets, bean bags, or tear gas. Price: $1,895. Crossfire LLC, 2169 Greenville Rd., LaGrange GA 30241.

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A pill that helps men with erectile dysfunction respond again.

Please see brief summary of product information for VIAGRA (25-mg, 50-mg, 100-mg) tablets on the following page.

Now there's a simple new pill for the treatment of erectile dysfunction (a common medical problem also called impotence).

VIAGRA™ (sildenafil citrate) is a prescription pill that may help you achieve erections the natural way—in response to sexual stimulation.

Naturally, the response has been positive.

With VIAGRA, you may be able to respond naturally once again—with the ease of a pill. Ask your doctor if VIAGRA is the right step for you.

VIAGRA should not be taken by men who use drugs known as nitrates (most often used to control angina) in any form, at any time. Nitrates can reduce blood pressure to unsafe levels if used with VIAGRA. Be sure to talk to your doctor about any medications you take.

In clinical trials, VIAGRA was well tolerated. Some men experienced side effects, including headache, facial flushing, and upset stomach. A small percentage of men experienced mild and temporary visual effects. (See product information for more details.) ***For more information, call 1-888-4VIAGRA or visit www.viagra.com.***

VIAGRA™
(sildenafil citrate) tablets

Let the dance begin.

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Let the dance begin.

Brief summary of prescribing information

VIAGRA™
(sildenafil citrate) tablets

INDICATION AND USAGE

VIAGRA is indicated for the treatment of erectile dysfunction. The studies that established benefit demonstrated improvements in success rates for sexual intercourse compared with placebo.

CONTRAINDICATIONS

Use of VIAGRA is contraindicated in patients with a known hypersensitivity to any component of the tablet. Consistent with its known effects on the nitric oxide/cGMP pathway (see CLINICAL PHARMACOLOGY), **VIAGRA was shown to potentiate the hypotensive effects of nitrates, and its administration to patients who are concurrently using organic nitrates in any form is therefore contraindicated.**

PRECAUTIONS

General

A thorough medical history and physical examination should be undertaken to diagnose erectile dysfunction, determine potential underlying causes, and identify appropriate treatment.

There is a degree of cardiac risk associated with sexual activity; therefore, physicians may wish to consider the cardiovascular status of their patients prior to initiating any treatment for erectile dysfunction.

Agents for the treatment of erectile dysfunction should be used with caution in patients with anatomical deformation of the penis (such as angulation, cavernosal fibrosis or Peyronie's disease), or in patients who have conditions which may predispose them to priapism (such as sickle cell anemia, multiple myeloma, or leukemia).

The safety and efficacy of combinations of VIAGRA with other treatments for erectile dysfunction have not been studied. Therefore, the use of such combinations is not recommended.

VIAGRA has no effect on bleeding time when taken alone or with aspirin. *In vitro* studies with human platelets indicate that sildenafil potentiates the antiaggregatory effect of sodium nitroprusside (a nitric oxide donor). There is no safety information on the administration of VIAGRA to patients with bleeding disorders or active peptic ulceration. Therefore, VIAGRA should be administered with caution to these patients.

A minority of patients with the inherited condition retinitis pigmentosa have genetic disorders of retinal phosphodiesterases. There is no safety information on the administration of VIAGRA to patients with retinitis pigmentosa. Therefore, VIAGRA should be administered with caution to these patients.

Information for Patients

Physicians should discuss with patients the contraindication of VIAGRA with concurrent organic nitrates.

The use of VIAGRA offers no protection against sexually transmitted diseases. Counseling of patients about the protective measures necessary to guard against sexually transmitted diseases, including the Human Immunodeficiency Virus (HIV), may be considered.

Drug Interactions

Effects of Other Drugs on VIAGRA

***In vitro* studies:** Sildenafil metabolism is principally mediated by the cytochrome P450 (CYP) isoforms 3A4 (major route) and 2C9 (minor route). Therefore, inhibitors of these isoenzymes may reduce sildenafil clearance.

***In vivo* studies:** Cimetidine (800 mg), a non-specific CYP inhibitor, caused a 56% increase in plasma sildenafil concentrations when co-administered with VIAGRA (50 mg) to healthy volunteers.

When a single 100 mg dose of VIAGRA was administered with erythromycin, a specific CYP3A4 inhibitor, at steady state (500 mg bid for 5 days), there was a 182% increase in sildenafil systemic exposure (AUC). Stronger CYP3A4 inhibitors such as ketoconazole, itraconazole or mibefradil would be expected to have still greater effects, and population data from patients in clinical trials did indicate a reduction in sildenafil clearance when it was co-administered with CYP3A4 inhibitors (such as ketoconazole, erythromycin, or cimetidine). It can be expected that concomitant administration of CYP3A4 inducers, such as rifampin, will decrease plasma levels of sildenafil.

Single doses of antacid (magnesium hydroxide/aluminum hydroxide) did not affect the bioavailability of VIAGRA.

Pharmacokinetic data from patients in clinical trials showed no effect on sildenafil pharmacokinetics of CYP2C9 inhibitors (such as tolbutamide, warfarin), CYP2D6 inhibitors (such as selective serotonin reuptake inhibitors, tricyclic antidepressants), thiazide and related diuretics, ACE inhibitors, and calcium channel blockers. The AUC of the active metabolite, N-desmethyl sildenafil, was increased 62% by loop and potassium-sparing diuretics and 102% by non-specific beta-blockers. These effects on the metabolite are not expected to be of clinical consequence.

Effects of VIAGRA on Other Drugs

***In vitro* studies:** Sildenafil is a weak inhibitor of the cytochrome P450 isoforms 1A2, 2C9, 2C19, 2D6, 2E1 and 3A4 (IC50 >150 μM). Given sildenafil peak plasma concentrations of approximately 1 μM after recommended doses, it is unlikely that VIAGRA will alter the clearance of substrates of these isoenzymes.

***In vivo* studies:** No significant interactions were shown with tolbutamide (250 mg) or warfarin (40 mg), both of which are metabolized by CYP2C9.

VIAGRA (50 mg) did not potentiate the increase in bleeding time caused by aspirin (150 mg).

VIAGRA (50 mg) did not potentiate the hypotensive effect of alcohol in healthy volunteers with mean maximum blood alcohol levels of 0.08%.

No interaction was seen when VIAGRA (100 mg) was co-administered with amlodipine in hypertensive patients. The mean additional reduction on supine blood pressure (systolic, 8 mmHg; diastolic, 7 mmHg) was of a similar magnitude to that seen when VIAGRA was administered alone to healthy volunteers (see CLINICAL PHARMACOLOGY).

Analysis of the safety database showed no difference in the side effect profile in patients taking VIAGRA with and without anti-hypertensive medication.

Carcinogenesis, Mutagenesis, Impairment of Fertility

Sildenafil was not carcinogenic when administered to rats for 24 months at a dose resulting in total systemic drug exposure (AUCs) for unbound sildenafil and its major metabolite of 29- and 42-times, for male and female rats, respectively, the exposures observed in human males given the Maximum Recommended Human Dose (MRHD) of 100 mg. Sildenafil was not carcinogenic when administered to mice for 18-21 months at dosages up to the Maximum Tolerated Dose (MTD) of 10 mg/kg/day, approximately 0.6 times the MRHD on a mg/m² basis.

Sildenafil was negative in *in vitro* bacterial and Chinese hamster ovary cell assays to detect mutagenicity, and *in vitro* human lymphocytes and *in vivo* mouse micronucleus assays to detect clastogenicity.

There was no impairment of fertility in rats given sildenafil up to 60 mg/kg/day for 36 days to females and 102 days to males, a dose producing an AUC value of more than 25 times the human male AUC.

There was no effect on sperm motility or morphology after single 100 mg oral doses of VIAGRA in healthy volunteers.

Pregnancy, Nursing Mothers and Pediatric Use

VIAGRA is not indicated for use in newborns, children, or women.

Pregnancy Category B. No evidence of teratogenicity, embryotoxicity or fetotoxicity was observed in rats and rabbits which received up to 200 mg/kg/day during organogenesis. These doses represent, respectively, about 20 and 40 times the MRHD on a mg/m² basis in a 50 kg subject. In the rat pre- and postnatal development study, the no observed adverse effect dose was 30 mg/kg/day given for 36 days. In non-pregnant rats the AUC at this dose was about 20 times human AUC. There are no adequate and well-controlled studies of sildenafil in pregnant women.

ADVERSE REACTIONS

VIAGRA was administered to over 3700 patients (aged 19-87 years) during clinical trials worldwide. Over 550 patients were treated for longer than one year.

In placebo-controlled clinical studies, the discontinuation rate due to adverse events for VIAGRA (2.5%) was not significantly different from placebo (2.3%). The adverse events were generally transient and mild to moderate in nature.

In trials of all designs, adverse events reported by patients receiving VIAGRA were generally similar. In fixed-dose studies, the incidence of some adverse events increased with dose. The nature of the adverse events in flexible-dose studies, which more closely reflect the recommended dosage regimen, was similar to that for fixed-dose studies.

When VIAGRA was taken as recommended (on an as-needed basis) in flexible-dose, placebo-controlled clinical trials the following adverse events were reported:

TABLE 1. ADVERSE EVENTS REPORTED BY ≥2% OF PATIENTS TREATED WITH VIAGRA AND MORE FREQUENT ON DRUG THAN PLACEBO IN PRN FLEXIBLE-DOSE PHASE II/III STUDIES

Adverse Event	Percentage of Patients Reporting Event	
	VIAGRA N=734	PLACEBO N=725
Headache	16%	4%
Flushing	10%	1%
Dyspepsia	7%	2%
Nasal Congestion	4%	2%
Urinary Tract Infection	3%	2%
Abnormal Vision*	3%	0%
Diarrhea	3%	1%
Dizziness	2%	1%
Rash	2%	1%

*Abnormal Vision: Mild and transient, predominantly color tinge to vision, but also increased sensitivity to light or blurred vision. In these studies, only one patient discontinued due to abnormal vision.

Other adverse reactions occurred at a rate of >2%,but equally common on placebo: respiratory tract infection, back pain, flu syndrome, and arthralgia.

In fixed-dose studies, dyspepsia (17%) and abnormal vision (11%) were more common at 100 mg than at lower doses. At doses above the recommended dose range, adverse events were similar to those detailed above but generally were reported more frequently.

No cases of priapism were reported.

The following events occurred in < 2% of patients in controlled clinical trials; a causal relationship to VIAGRA is uncertain. Reported events include those with a plausible relation to drug use; omitted are minor events and reports too imprecise to be meaningful:

Body as a whole: face edema, photosensitivity reaction, shock, asthenia, pain, chills, accidental fall, abdominal pain, allergic reaction, chest pain, accidental injury.

Cardiovascular: angina pectoris, AV block, migraine, syncope, tachycardia, palpitation, hypotension, postural hypotension, myocardial ischemia, cerebral thrombosis, cardiac arrest, heart failure, abnormal electrocardiogram, cardiomyopathy.

Digestive: vomiting, glossitis, colitis, dysphagia, gastritis, gastroenteritis, esophagitis, stomatitis, dry mouth, liver function tests abnormal, rectal hemorrhage, gingivitis.

Hemic and Lymphatic: anemia and leukopenia.

Metabolic and Nutritional: thirst, edema, gout, unstable diabetes, hyperglycemia, peripheral edema, hyperuricemia, hypoglycemic reaction, hypernatremia.

Musculoskeletal: arthritis, arthrosis, myalgia, tendon rupture, tenosynovitis, bone pain, myasthenia, synovitis.

Nervous: ataxia, hypertonia, neuralgia, neuropathy, paresthesia, tremor, vertigo, depression, insomnia, somnolence, abnormal dreams, reflexes decreased, hypesthesia.

Respiratory: asthma, dyspnea, laryngitis, pharyngitis, sinusitis, bronchitis, sputum increased, cough increased.

Skin and appendages: urticaria, herpes simplex, pruritus, sweating, skin ulcer, contact dermatitis, exfoliative dermatitis.

Special senses: mydriasis, conjunctivitis, photophobia, tinnitus, eye pain, deafness, ear pain, eye hemorrhage, cataract, dry eyes.

Urogenital: cystitis, nocturia, urinary frequency, breast enlargement, urinary incontinence, abnormal ejaculation, genital edema and anorgasmia.

OVERDOSAGE

In studies with healthy volunteers of single doses up to 800 mg, adverse events were similar to those seen at lower doses but incidence rates were increased.

In cases of overdose, standard supportive measures should be adopted as required. Renal dialysis is not expected to accelerate clearance as sildenafil is highly bound to plasma proteins and it is not eliminated in the urine.

HC150R98

VIAGRA™
(sildenafil citrate) tablets

XC614A97

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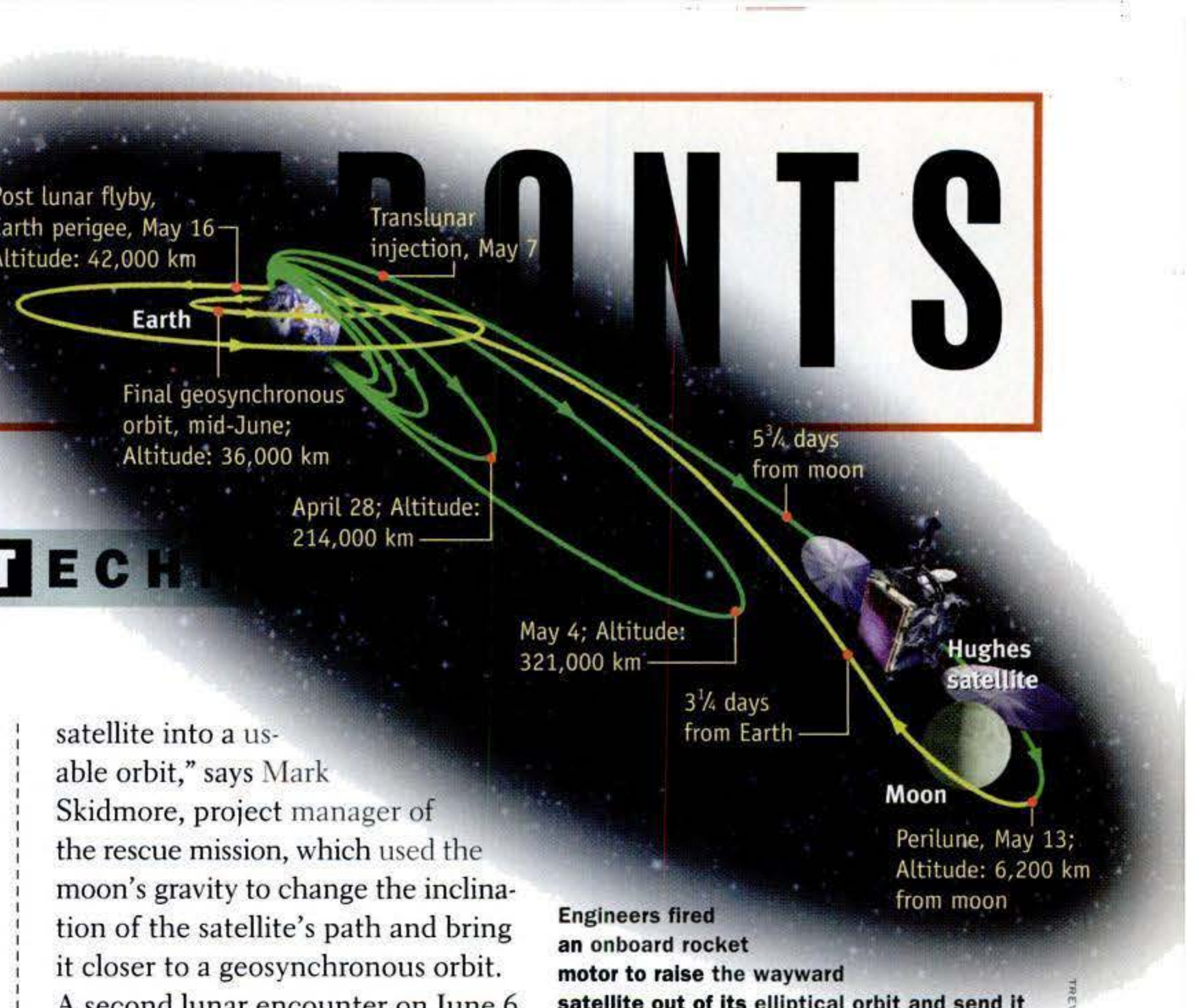
NEW FRONTS

SCIENCE & TECH

EDITED BY DAWN STOVER



Engineers fired an onboard rocket motor to raise the wayward satellite out of its elliptical orbit and send it around the moon. The moon's gravity flung the satellite back into a usable Earth orbit.

TREVOR JOHNSTON

SPACE

Moon Mission

COWS MAY NOT be able to jump over the moon, but one company has proved that a satellite can do it. In a series of maneuvers devised by engineers at Hughes Global Services, the HGS-1 satellite recently orbited the moon on its way to a final position above Earth's equator. It was the first time a lunar gravity assist has been used to boost a commercial satellite.

Hughes engineers came up with the strategy after a failed launch stranded the satellite—originally intended to provide communications services to Asia—in a lower orbit than planned. "It was such a substantial performance problem with the rocket that we couldn't get the satellite into a usable orbit," says Mark Skidmore, project manager of the rescue mission, which used the moon's gravity to change the inclination of the satellite's path and bring it closer to a geosynchronous orbit. A second lunar encounter on June 6 improved HGS-1's orbit even more.

Hughes' strategy posed such risks as thermal damage and communications loss because the satellite was sent a greater distance than originally planned. "It was never intended to go anywhere near the moon, and [Hughes engineers] weren't sure if it would be possible to communicate with it or if it would experience other problems onboard," says Dave Folta, an aerospace engineer at NASA Goddard's Guidance Navigation and Control Center.

The gravity-assist method seemed to be the only viable strategy to salvage HGS-1. "It takes a lot of fuel from a spacecraft to change its inclination," says Skidmore. The lunar gravity assists used fewer fuel-consuming maneuvers than conventional repositioning strategies.

The strategy conserved enough fuel to keep HGS-1 in orbit for 10 to 15 years. The satellite won't be able to do its original job, but it may be able to provide other communications services.—*Erin Cassin*

TRANSPORTATION

Storing Energy on the Run

ENGINEERS AT THE UNIVERSITY of Texas Center for Electro-Mechanics in Austin are developing a propulsion system that promises to make commuter trains faster. The Advanced Locomotive Propulsion System mates a lightweight gas turbine with a flywheel—a type of battery that stores energy electromechanically rather than electrochemically.

The 4,000-horsepower AlliedSignal TF40 turbine, similar to those used in airplanes, will propel the locomotive. The turbine reaches its optimum fuel efficiency when it runs nonstop at top speed. But commuter trains accelerate and decelerate frequently to negotiate curves and hills, and to make stops at stations. That's where the flywheel comes in.

When the train is braking, the energy produced by the turbine isn't needed to propel the locomotive. Instead, it's used to spin the flywheel at speeds up to 1,000 meters per second inside a vacuum casing with low-friction bearings. The flywheel can be recharged more quickly than electrochemical batteries, and it works better in cold weather.

The flywheel also captures kinetic energy during braking. The stored energy can later be used to boost acceleration.

Most passenger trains currently run at speeds up to 80 mph. The flywheel train, due in 2001, will reach 125 mph.—*Kim Fraser*

In the new locomotive, the gas turbine (right) will be attached to a generator (left).

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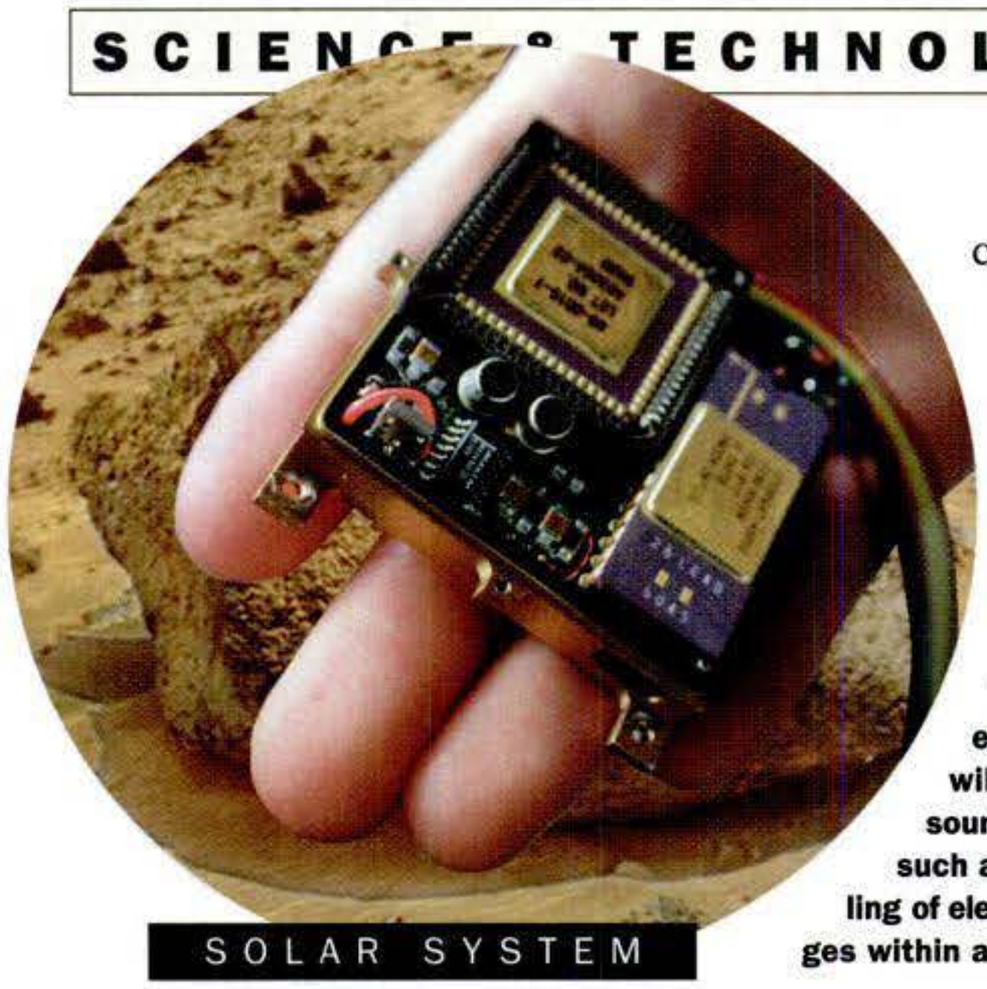

SOLAR SYSTEM

R. WEINER/ASSOCIATED PRESS

Eavesdropping on Mars

NASA'S NEXT MARS lander will carry something never before sent to another planet: a tiny listening device to capture out-of-this-world sounds.

Built at the University of California's Space Sciences Laboratory in Berkeley, the Mars Microphone is a creation of The Planetary Society, a nonprofit space advocacy group once led by Carl Sagan. The Society not only sold the idea to NASA, but also financed the project, and even found a place for it on a Russian experimental module scheduled to fly aboard the Mars Surveyor in January 1999.

The microphone was designed, built, and tested for a mere $50,000. According to chief engineer Greg Delory, the Berkeley team used the same sort of cheap, reliable electronics now found in hearing aids, home computers, and children's toys.

Still, when Sagan first proposed the project to NASA, the agency was reluctant to add another instrument to Surveyor. Help came from scientists working on an atmospheric experiment that will be the first Russian payload ever to fly on a U.S. planetary mission. The Russians agreed to let the Mars Microphone hitch a ride on their platform, even though it meant sacrificing a portion of the experiment's power and communications.

This palm-size electronic device will listen for sounds on Mars, such as the crackling of electrical discharges within a sandstorm.

Even so, the microphone will be allowed only a tiny piece of the data stream that Surveyor radios back to Earth. The system will listen for about a week, then relay back just 10 seconds of sound. Unless commanded otherwise, it will play back the loudest sounds it hears.

What will the microphone hear? Wind, mostly, plus the occasional spacecraft noise. With a little luck, the mike may pick up the sound of electrical discharges occurring within a martian sandstorm. "The most exciting sound we're going to hear," says Delory, "is the one we don't know about."—*S. Matthew Sabatini*

THE BRAIN

Quick Thinking

RESEARCHERS AT Johns Hopkins University are learning more about how the brain processes information. While treating a 22-year-old man who was a long-time sufferer of severe epileptic seizures, a team of doctors decided it was necessary to remove part of his brain. To find out which part was malfunctioning, they temporarily implanted 174 electrodes on the brain's surface. This was the perfect opportunity for an experiment: clocking the speed of the man's thoughts.

By using a mild electrical current to short-circuit brain activity at different time intervals, the team—led by neurologist Dr. John Hart—discovered that it took the patient 250 to 450 milliseconds, or less than half a second, to fully comprehend a picture of an ordinary object. Hart says knowing the speed at which the brain processes information is critical to understanding how it works.—*D.S.*

ENVIRONMENT

Technologies for A Cleaner World

A DECADE FROM NOW, cars will get 80 miles to a gallon, crops will be genetically engineered to require fewer pesticides, and houses will be heated by tiny heat pumps embedded in the walls. Those are among the predictions of an environmental technology forecast prepared by a team of researchers at the Department of Energy's Pacific Northwest National Laboratory in Richland, Washington.

The researchers identified what they say are the 10 most important technologies that will lead to a cleaner environment by the year 2008. Among the highlights:

GENETIC ENGINEERING of plants will not only make foods taste better, but will also reduce the need for pesticides, fertilizers, and water.

"SMART" FILTERS will improve water treatment by automatically unclogging themselves.

MICRO HEAT PUMPS will provide energy-efficient space heating, and micro chemical plants will eliminate the need for storage and transportation by producing industrial chemicals onsite.

ADVANCED DISPLAYS and wireless communications will lead to a paperless society.

BIOPROCESSING will enable industry to "grow" drugs and fuels using microorganisms and plants.

REAL-TIME SENSORS will enable supermarkets to instantly detect contaminants in food.

NEW MATERIALS such as composite glass—a sandwich of glass and plastic—will make cars lighter and more fuel-efficient.

The complete technology forecast is available on the World Wide Web at *www.pnl.gov/news*.—*D.S.*

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MEDICINE

Inhaling Insulin

DIABETICS WHO REQUIRE daily insulin injections may soon be able to throw away their needles. Scientists have come up with a new method for taking the medication: inhaling it.

The idea for the new delivery method emerged more than a decade ago, when a scientist at Cornell University's Boyce Thompson Institute for Plant Research was studying how plant seeds survive drying. Carl Leopold discovered that sugars in corn and soybean seeds go into a glassy state when dried, preserving essential enzymes and proteins. The hard, clear sugar particles dissolve when rehydrated, allowing the seeds to germinate and grow. Leopold reasoned that other enzymes—including pharmaceuticals such as insulin—might also be stabilized in a dry form.

The insulin delivery device is about three times the size of inhalers used by asthmatics.

Inhale Therapeutic Systems of San Carlos, California, is now able to turn liquid insulin into a stable powder by combining Leopold's technique for drying molecules with a complementary technique from Felix Franks of Cambridge University. A process called spray drying creates particles that are 1 to 5 microns in diameter—any smaller and the insulin would be breathed out like cigarette smoke.

The drug is taken using a flashlight-size aerosol inhaler that expands to about a foot high. A foil-wrapped drug packet is inserted into the device, which discharges a powdery cloud of dried insulin that the patient inhales in one deep breath. The insulin quickly rehydrates in the moist lungs, then passes through the thin layer of alveoli cells lining the lungs and enters the bloodstream.

The final phase of human clinical trials for the new drug is expected to begin later this year.—*Patricia Barnes-Svarney*

FOSSILS

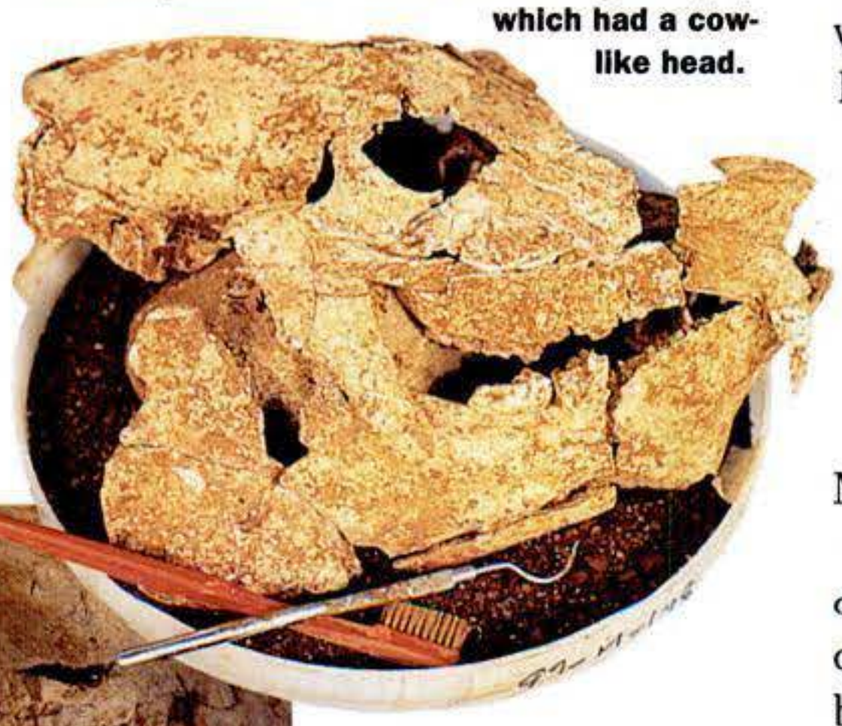
Searching for Giant Lemurs

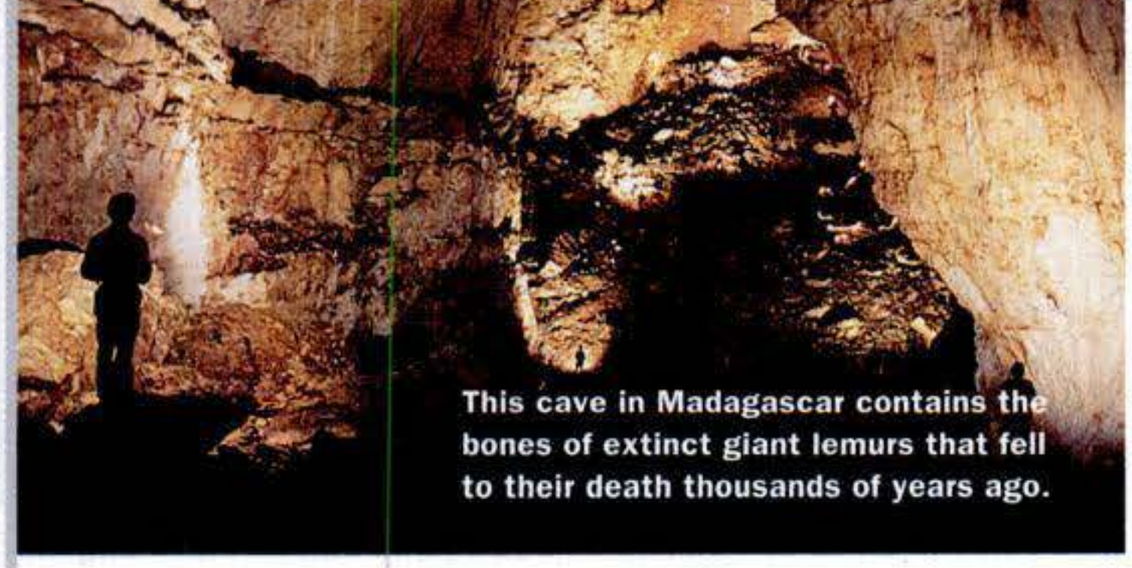
MY CLIMBING harness cuts into my flesh as I lower myself into a pitch-black, 600-foot-deep pit. A squawking and flapping ruins my concentration—my awkward movements have disturbed the large black vasa parrots that nest in the walls and give the Cave of the Parrots its name.

Below me, four other cavers have already made their descent. I have come to photograph them as they unearth the remains of giant lemurs that met their deaths when they plunged into this deadly pit on the island of Madagascar thousands of years ago. We are part of the latest Duke University Primate Center expedition, led by veteran primatologist Elwyn Simons.

Today's surviving lemurs are small and agile. Larger lemurs, whose size and slowness made them easy targets, have already been hunted into extinction. Those giant lemur species were also the ones most likely to fall into the hundreds of limestone caverns that pock the Madagascar landscape—tragic for them, but lucky for primatologists trying to understand the lives of these strange animals.

Fossils recovered from the cave include the skull of a chimpanzee-size lemur called Megaladapis, which had a cow-like head.





This cave in Madagascar contains the bones of extinct giant lemurs that fell to their death thousands of years ago.

Among the animals that once lived in Madagascar is a 100-pound sloth lemur that spent almost its whole life literally hanging around. By examining hundreds of bones retrieved from the Cave of the Parrots, Simons and other primatologists hope to learn more about how these lemurs locked their limbs to hang upside down comfortably. Duke will share the bones with the Malagasy government.

"The rubble deposit at the bottom of that cave appears to be the size of several houses," says Simons. The bottom of the pile could contain fossils that have never been seen before, animals that became extinct 100,000 years ago, says Simons. He proposes that future workers build a mine elevator down into the cave and burrow tunnels into the sides of the great mound to hasten the exploration of this paleontological treasure trove.—*Chris Hildreth*

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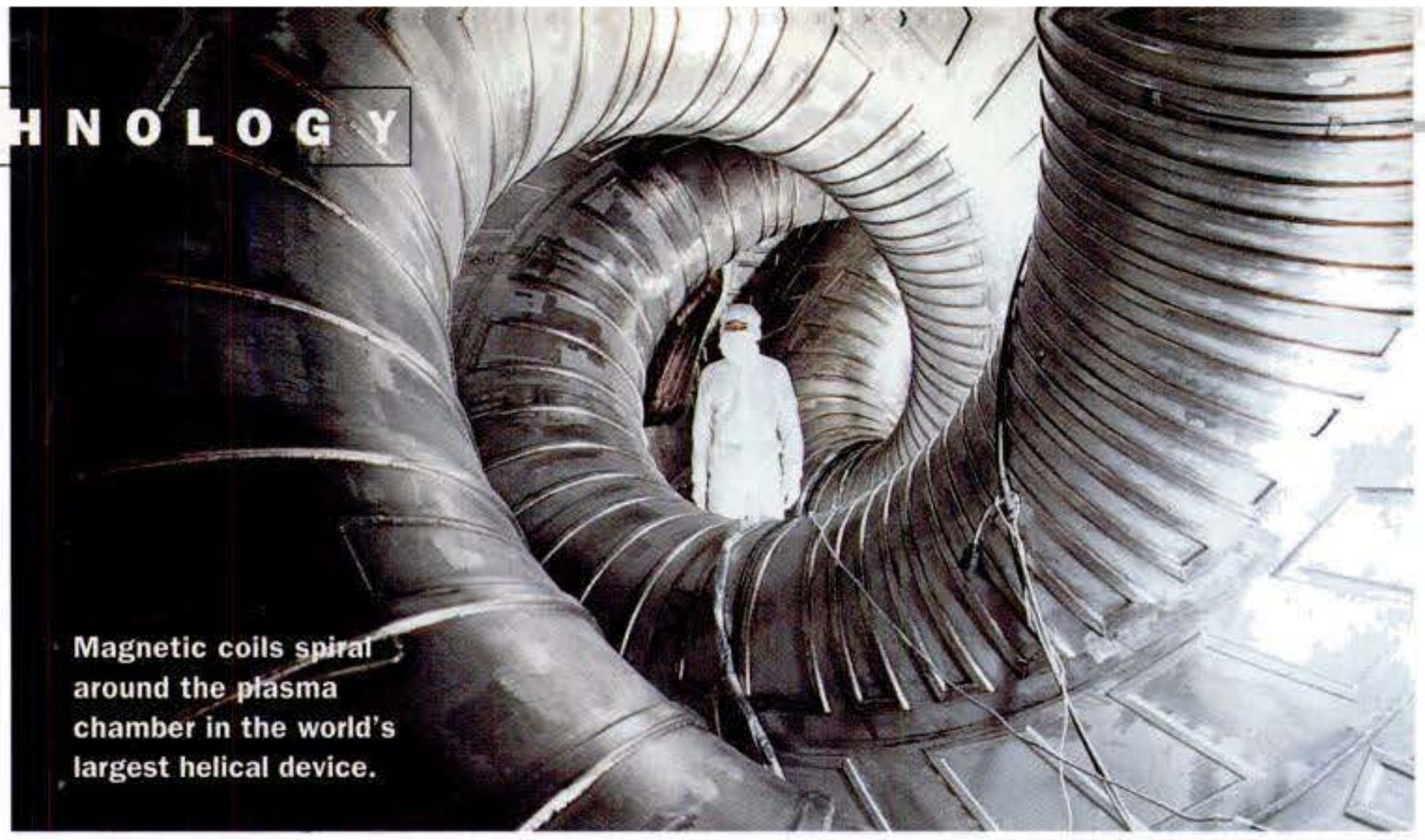
PHYSICS

Fusion Alternative



Magnetic coils spiral around the plasma chamber in the world's largest helical device.

FOR DECADES, most researchers striving to harness fusion energy have used devices known as tokamaks. But researchers in Japan are out to demonstrate that a competing approach is a candidate for the fusion power reactors envisioned for the mid-21st century. Their $650 million Large Helical Device (LHD), the world's largest, started operating this spring at Japan's National Institute for Fusion Science near Nagoya.

Both tokamaks and helical devices are designed to fuse isotopes of hydrogen into helium, the energy-generating process that drives the sun and stars. To start a fusion reaction on Earth requires heating a plasma of hydrogen isotopes to 100 million degrees Celsius, so that positively charged gas nuclei can overcome their natural repulsion and fuse.

In both tokamaks and helical devices, the heated plasma is trapped within a spiraling magnetic field inside a doughnut-shaped vacuum vessel. The tokamak uses a combination of two magnetic fields, one created by coils placed in rings spaced around the doughnut, and one produced by a current running through the plasma itself. In a helical device, the magnetic field is created entirely by coils wound around the doughnut in a spiral, something like the ribs on a French cruller. The LHD won't be able to match the plasma temperatures or densities already achieved in tokamaks. But whereas tokamaks can only confine the plasma for minutes at a time, the LHD can hold the plasma in a steady state for hours or even days.—*Dennis Normile*

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FOODS

Some Like It Hot

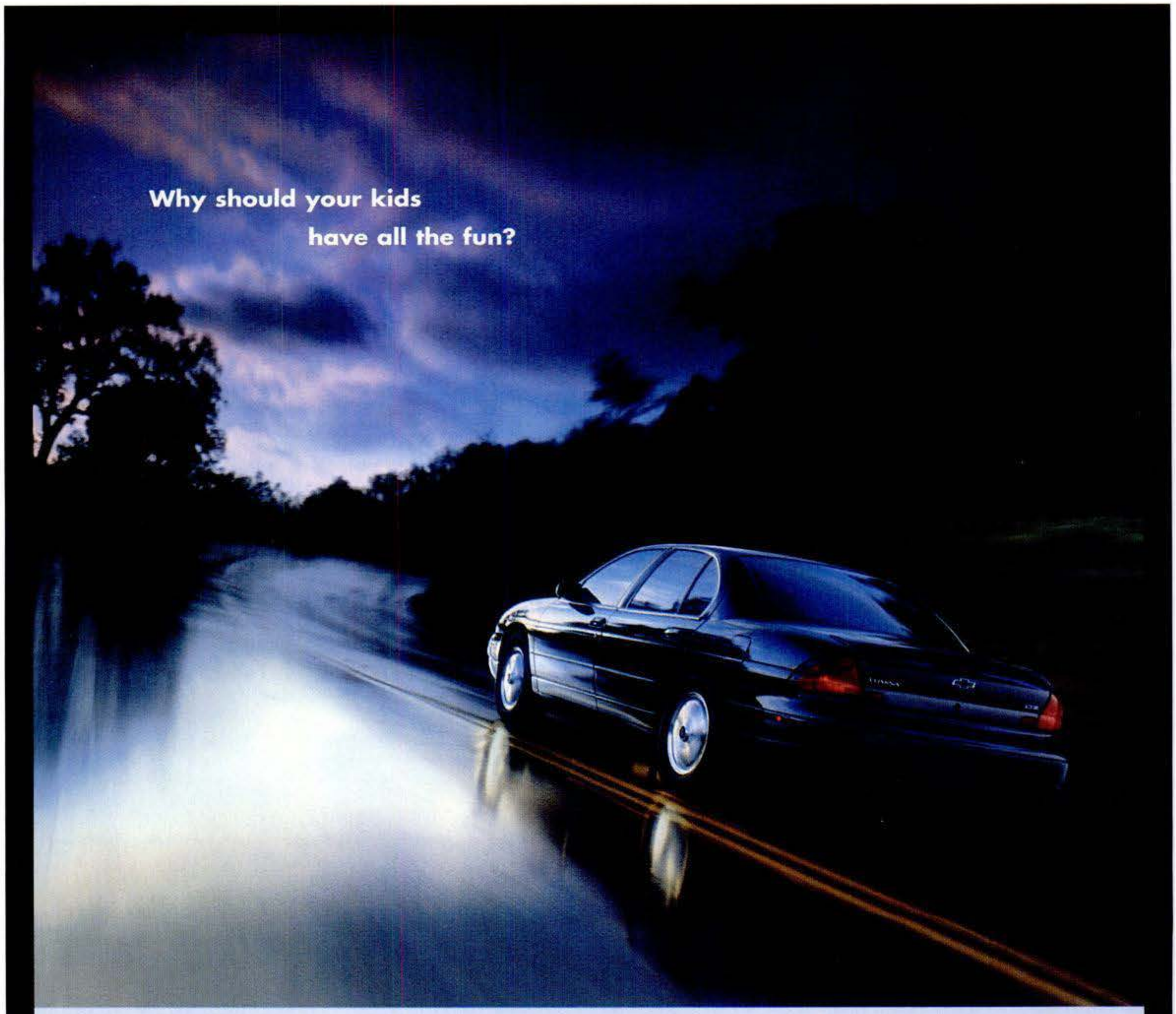
WHY DO PEOPLE IN THAILAND prefer spicier food than people in Sweden? It's because spices offer some protection against the food-spoilage bacteria that thrive in hot climates, according to two biologists at Cornell University in Ithaca, New York.

After analyzing thousands of recipes for the traditional meat-based dishes of 36 countries, Jennifer Billing and Paul W. Sherman conclude that countries with hotter climates use spices more frequently than countries with cooler climates. And within large countries such as the United States, the hottest regions have the hottest foods: Chili is a hit in San Antonio, while chilly Boston tends toward clam chowder.

A taste for spices has been passed down over many generations. In hot climates, our ancestors who enjoyed spices with their food were apt to live longer and produce more offspring, says Sherman. "And they taught their offspring and others: 'This is how to cook a mastodon.'"—*D.S.*

Spice World

Not all spices are created equal. The 10 with the greatest effectiveness against food-spoilage bacteria are listed here.



A parent isn't always "on-duty." And once you've dropped off the kids, you'll appreciate Lumina® LTZ and its available 200-hp 3800 V6. You'll enjoy going 0–60 quicker than a Taurus SE, Intrepid ES or Camry LE.* The 225 lb.-ft. of torque. The way it tracks – solid and true. Now don't worry – it's still a Lumina, with all its well-earned reputation for reliability. It has a comprehensive safety package, even a standard theft-deterrent system. In fact, Lumina LTZ has all those practical things you normally find in a midsize car. Plus all those cool things you don't.

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COMPUTERS & SOFTWARE

EDITED BY CHRIS O'MALLEY

DIGITAL IMAGING

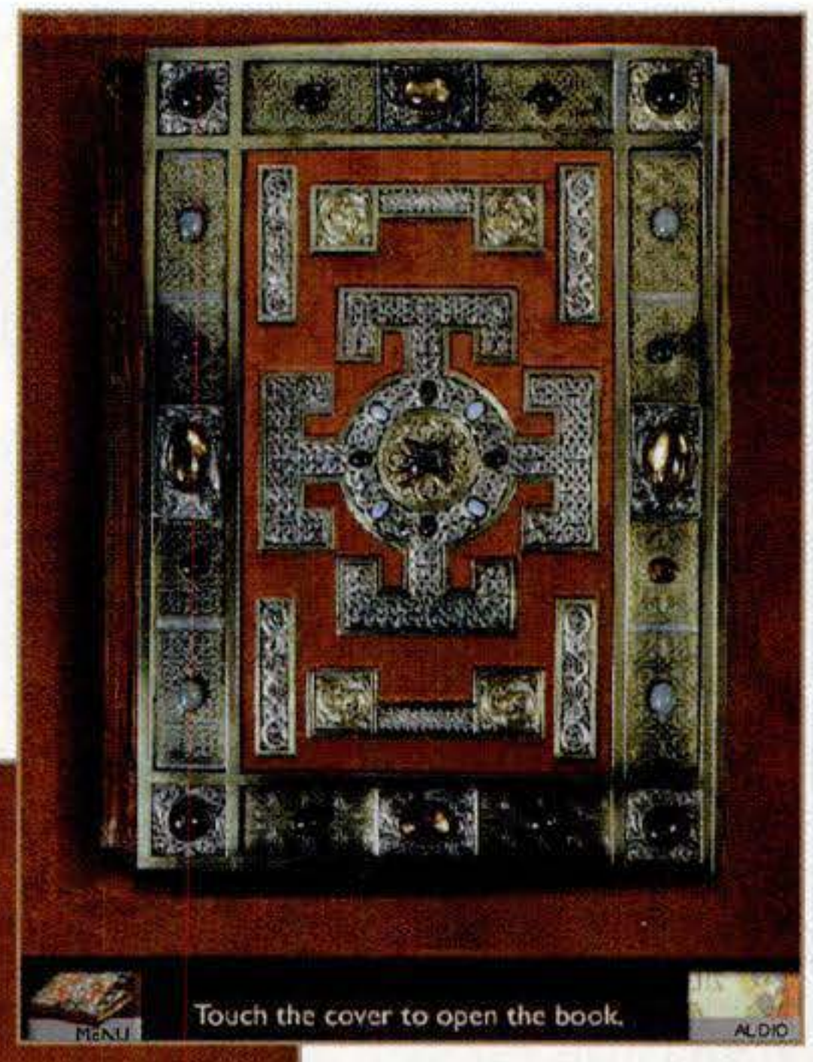
Turning Electronic Pages

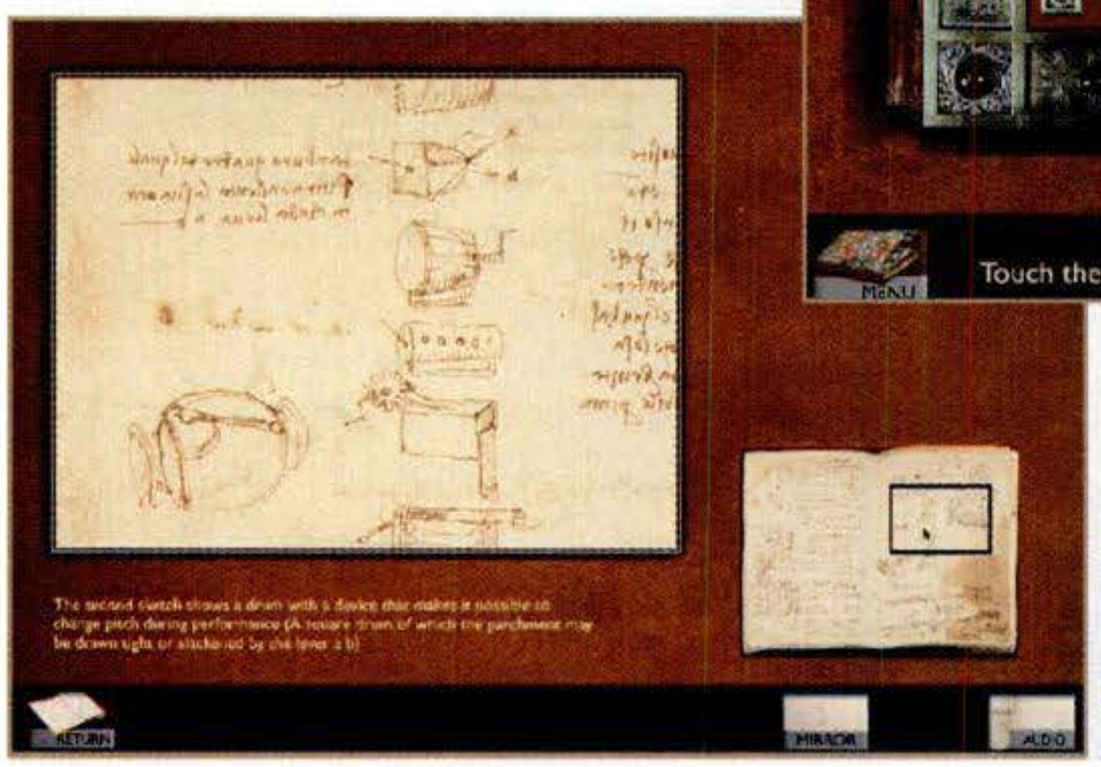
LITERALLY TURNING the page on a new chapter in literary history, the British Library in London recently introduced a computerized system that lets readers electronically turn the pages of priceless and fragile manuscripts.

So far, four works have been partially digitized: Leonardo da Vinci's notebook, the *Codex Arundel*; *The Sforza Hours*, a superb example of Renaissance illumination; the *Diamond Sutra*, the world's first recorded printed book, produced in 868 A.D.; and the *Lindisfarne Gospels*, written between 698 and 721 A.D. About 16 pages of each work have been digitized and combined with animated page turns to approximate the look and feel of the real manuscript. Other manuscripts, including the Magna Carta, will be part of this Treasures Digitalization project as well.

To thumb through these treasures, you touch a corner of the page displayed on the computer screen and drag your finger across the page, prompting the onscreen page to turn.

A new computer system at the British Library lets you electronically turn the pages of fragile documents such as da Vinci's notebook (below), the *Lindisfarne Gospels* (right), and the *Diamond Sutra* (below right).





The system simulates the way both vellum and paper move, and also how scrolls roll and unroll. It includes a zoom feature and audio commentary, and can even reverse da Vinci's handwriting so it can be read left to right. Eventually, the rustle of pages may be added for an ever more realistic effect, according to Clive Izard, head of Audio Visual Services.

So far, the system consists of five computers that can access these digitized documents. And since it was designed as a gallery exhibit, you have to be there. A fully functional Internet version is unlikely any time soon, explains Izard, because the speed required to achieve the real-time animation of turning high-resolution pages is more than most Internet connections can handle. For now you can see still shots and read translations on the British Library's site at *www.bl.uk.—Gail Dutton*

INTERNET

ADSL May Come ASAP

THE COMPUTER AND TELEPHONE companies are determined not to let ADSL turn into ISDN. Despite the lip-tripping acronyms, this may actually make your life a little easier.

ADSL, or asymmetric digital subscriber line, is the digital phone service that promises much faster Internet access than today's phone-line modems, even while providing voice service on the same line. ISDN, or integrated services digital network, is the digital phone service that for many years has promised similar benefits, but never gained a foothold with consumers due to its costs and complexities. Earlier this year, however, the largest phone and PC companies agreed to create a universal standard for ADSL modems, and that effort appears to be paying off.

Compaq, Dell, and IBM intend to include ADSL modems as standard features on some of their new PCs this fall. In each case, a 56Kbps modem will be included for use where there is no ADSL service. But service is clearly on the way. BellSouth, GTE, and US West each say they will offer ADSL services in some of the cities they serve later this year. Ameritech, Southwestern Bell, and others will do the same. Speeds will range from 256Kbps to 1.5Mbps, with monthly fees ranging from $30 to $250.—*C.O.*

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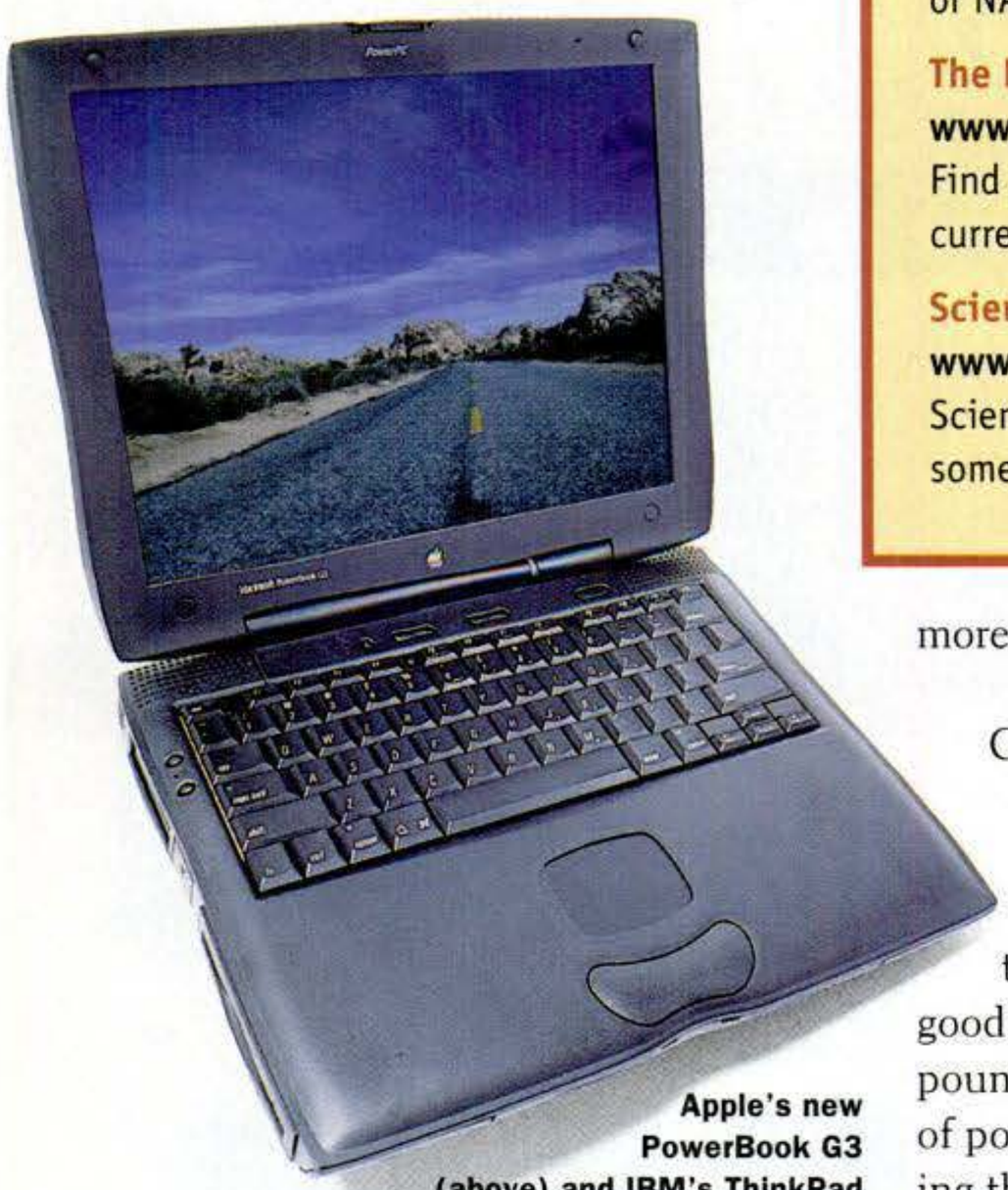
HANDS ON

Laptop Moderation

LAPTOP COMPUTERS have always been a cash and carry affair—if you wanted the cachet of a top-notch notebook, such as an IBM ThinkPad or an Apple PowerBook, you'd better be carrying a lot of cash. That's now changing, albeit slowly.

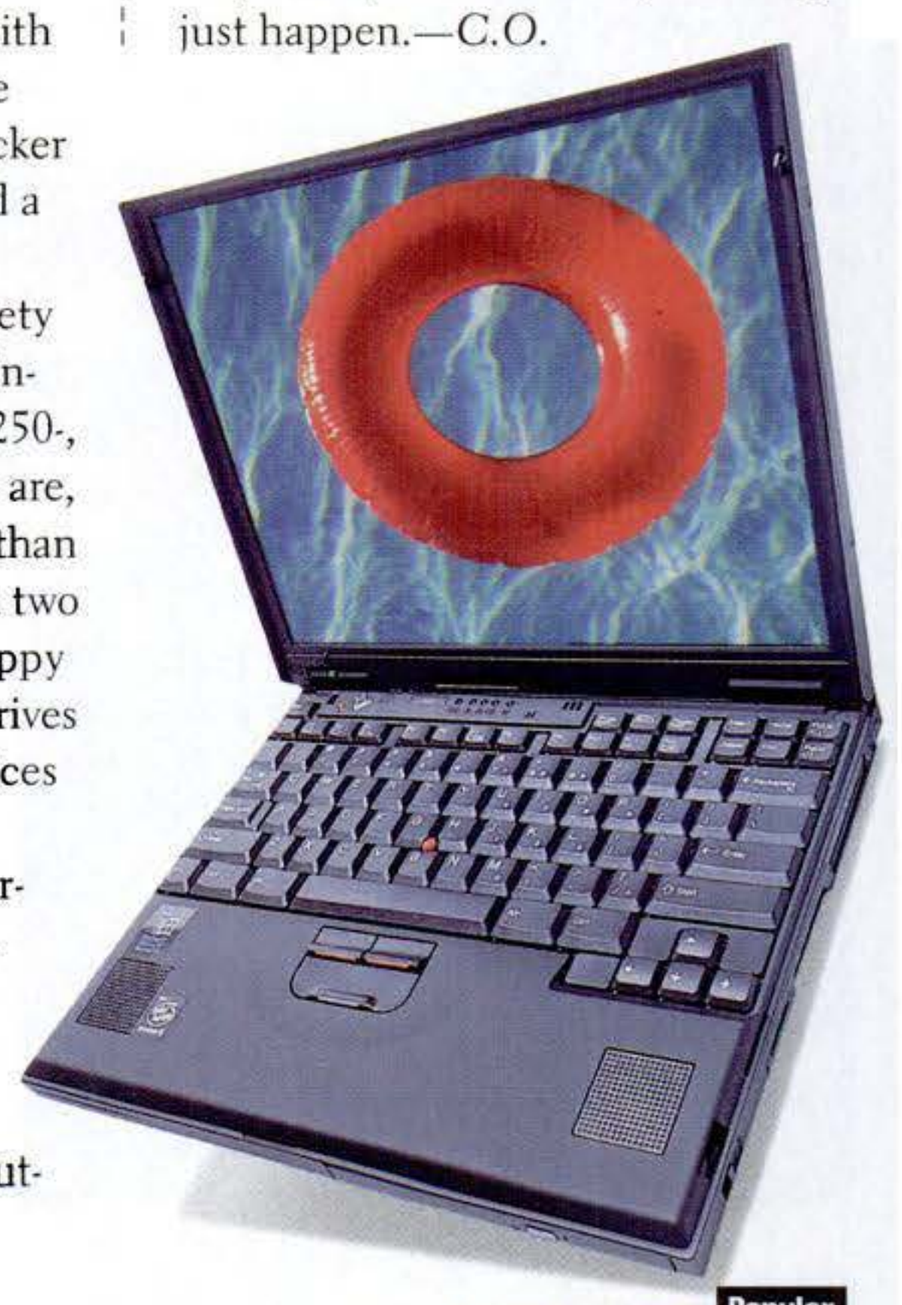
IBM's new ThinkPad 600 series brings the thin, black chic of its ThinkPad predecessors—many costing more than $5,000—down to more reasonable realms. The basic 600 model purrs along on a 233MHz Pentium chip and packs 32MB of memory, a 3.2GB hard disk, swappable CD-ROM and floppy drives, a 56Kbps modem, and a 13-inch dual-scan color screen that's brighter than most passive-matrix panels. It's all in a sleek package that weighs less than 5.5 pounds and costs $2,799. At the other end of the spectrum is our no-compromises test model, which has similar specs save for a 266MHz Pentium II chip and a vivid active-matrix screen. But this charmer has a much more ThinkPad-like price of $4,599.



Apple's new PowerBook G3 (above) and IBM's ThinkPad 600 (right) bring style and power to the midrange laptop category.

Apple's new PowerBook G3 series blends the speed of PowerPC G3 processors with curvaceous styling. These models are larger and thicker than the ThinkPad 600, and a good bit heavier at about 7 to 8 pounds. But they come in a variety of potent configurations. Headlining the list of features are 233-, 250-, and 292MHz G3 processors that are, hertz for hertz, noticeably faster than Pentium counterparts. And with two drive bays, you can also keep floppy and CD-ROM (or DVD-ROM) drives in the unit at the same time. Prices range from $2,299 to $5,599.

The ThinkPad 600 and PowerBook G3 models are superb laptops, designed to lure people in the respective Windows and Macintosh camps to invest in high-performance mobile computers. With capabilities that rival desktops and prices that, in some cases, only mildly exceed them, that might just happen.—C.O.



WEB WATCH

Missile Threats and Responses
www.cdiss.org
A comprehensive look at missile dangers and defenses, past and present, with an overview of missile payloads and who's got what pointed where.

Reefs of the Gulf
gulftour.tamu.edu/home.html
Tour the depths of the Gulf of Mexico by submarine with Texas A&M scientists as your guides.

Live Racing
www.liveracing.com
Listen to live in-car race coverage of NASCAR Winston Cup races.

The Everything Calculator
www.calculator.com
Find a reckoner for any occasion, from currency exchange to men's suit sizes.

Science a Go-Go
www.scienceagogo.com
Science stories with an offbeat and sometimes humorous twist.

Fox News Video
www.foxnews.com/video
Assemble your own personalized broadcast from video clips.

The Chemical Scorecard
www.scorecard.org
Check out the pollutants and other hazards within your county.

The Showroom of Automotive History
www.angelfire.com/me/HOFF
A photo of every Corvette model year since 1953.

The Wind-Up Toy Company
www.winduptoyco.com
Catalog of wind-up toys in every shape and size.
—Suzanne Kantra Kirschner

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WIRELESS DATA

Blue Blazing Bits

GETTING ONE computer device to talk to another without wires can be nearly as tedious as root canal. Now, a technology code-named Bluetooth could help ease the pain.

Bluetooth uses short-range radio frequency transmitters to wirelessly zap information between portable devices such as laptop computers, organizers, and cellular phones. This radio system offers several key advantages over infrared transmission, the primary method used today. Bluetooth has a 30-foot range, and moves data more quickly than infrared. And unlike infrared, it also can transmit through and around objects. That will make possible new twists such as sharing e-mail messages between laptop computers and cellphones, even when the laptop is in a briefcase.

Bluetooth is backed by Compaq, Ericsson, IBM, Intel, Motorola, Nokia, Toshiba, and 3Com. Products using the new transmitters are not expected until next year.—*C.O.*

HANDS ON

Multimedia Junction

MOST OF US have more video footage of birthdays and vacations than anyone will ever want to watch. But most video-editing gear is too costly, too complicated, or both. Enter Iomega's Buz, a "multimedia producer" for PCs that puts real editing tools in your hands for $199.

Iomega's Buz serves as a hub for getting video and audio clips into your PC, and then back out to tape.

Buz, an odd-looking purple device that cables to a Windows PC via an included SCSI card, serves as the hub for getting video images into and out of your computer. In between, you can edit the video and audio using the included software. The results can be saved in digital video format on disks (including disks from Iomega's own Zip and Jazz drives) or recordable CDs, or your images can be copied back to videotape. Buz has composite video in and out ports, plus S-Video in and out.

Buz lets you choose from three levels of resolution, depending on the intended use of the video. Lower resolutions require less disk space, but image quality suffers. High-resolution video is best for output to tape, but it uses nearly 120MB per minute, so a 1- or 2-gigabyte removable media device is highly recommended. The resulting video is still visibly degraded from the original, but probably no more than a dubbed tape. Once you assemble your clips and add your titles and transitional effects (such as screen wipes), your PC must process the video, which can take 20 minutes or more.

Buz is not for would-be James Camerons looking to produce the next *Titanic*. But if you've got too much home video on your hands, your ship may have finally come in.—*Dan Carney*

GAMES

Immersive Idling

AS IF computer games weren't addictive enough, the latest in game technology may cause you to forget you're even at the computer.

Many of the best new games have 3-D environments with a cinematic quality, including accurate lighting effects, and weather effects like fog and rain. In SimCity 3000, by Maxis, pedestrians walk down streets lined with carefully detailed buildings while seemingly real cars go whizzing by. Grim Fandango, by Lucas Arts, is another beautifully rendered game that takes its look from Mexico's Day of the Dead art. The main character, Manny, is a travel agent who escorts people to the Land of the Dead, where he has to foil an evil plot.

Some of these games may fool your ears too. So-called 3-D audio (basically getting surround sound effects from two computer speakers) has been around in some form for several years, but the increasing support for Aureal's 3DA and Microsoft's DirectSound 3D technologies has made it a part of many more titles. You'll really need the sound cues in Eidos' Thief: The Dark Project, a shoot-'em-up in which hearing your enemies approach is critical. Sound is also key in Forsaken, by Acclaim Entertainment, which has you hurtling through a large maze of tunnels in a flying machine. More than 100 games are expected to support 3-D audio by year end.—*S.K.K.*

New games such as Foresaken (top left), FireTeam (left), and Eidos' Thief: The Dark Project (above) add new 3-D realism to the gaming experience, both for graphics and for sound.

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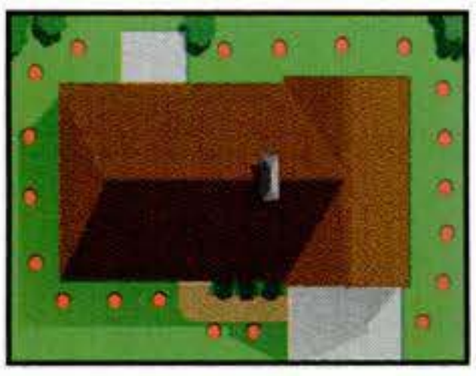
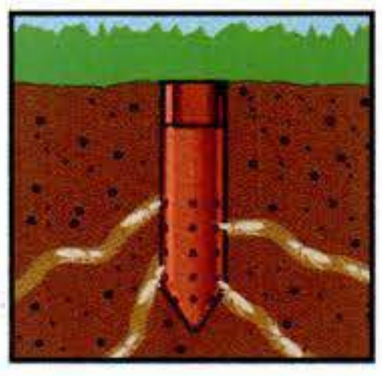


APPLY: *Simply place the stakes in the ground around your home, and TERMINATE does the work.*



FEED: *Worker termites foraging for food find the stakes, eat the insecticide coated food, and die.*

TERMINATE: *Without workers to supply the colony with food, the remaining termites die.*

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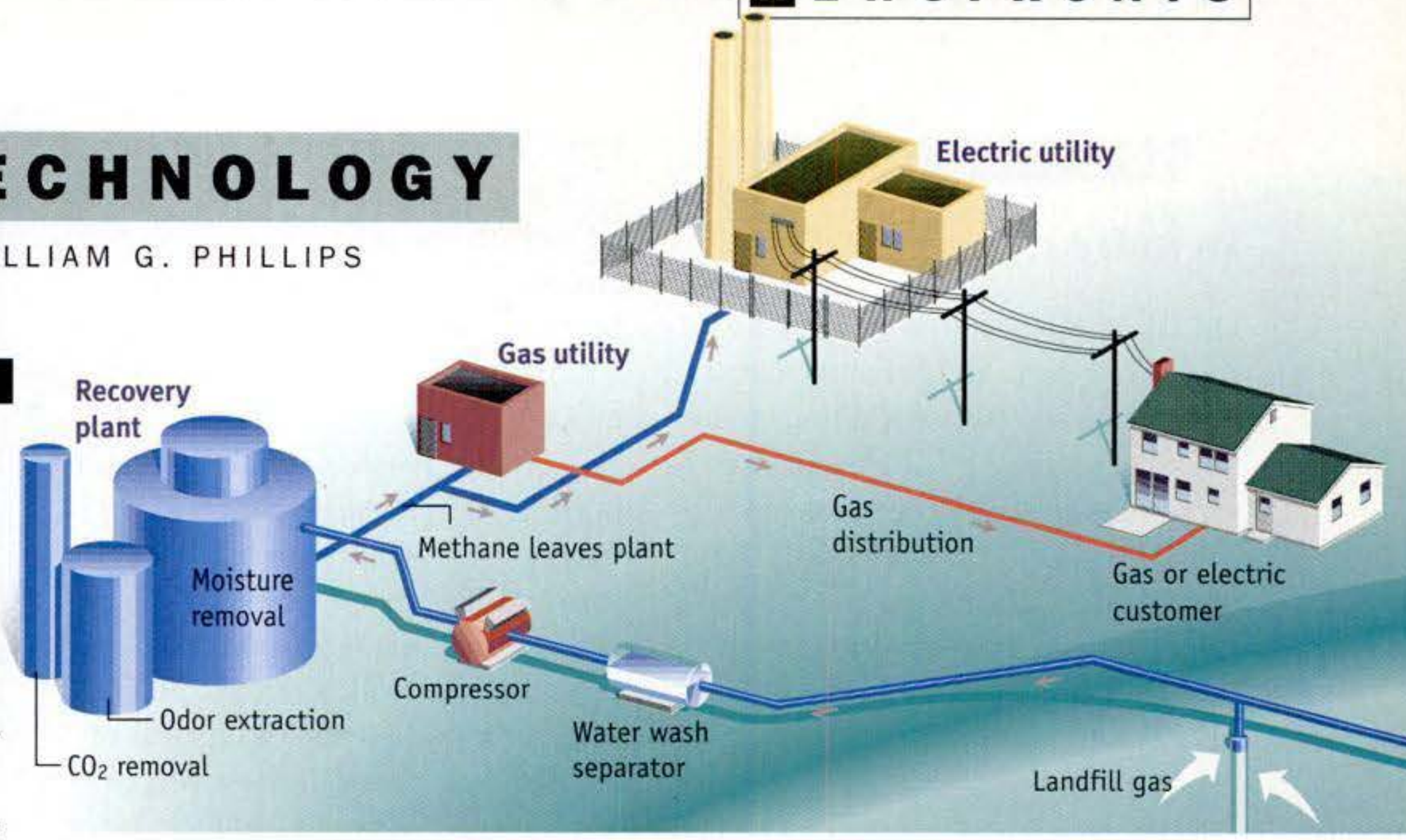
HOME TECHNOLOGY

EDITED BY WILLIAM G. PHILLIPS

POWER GENERATION

Electric Landfills



After being collected, landfill gases are separated into carbon dioxide and methane. The former can be used industrially, while the latter can be turned into power at utilities or directly at homes.

GREG MAXSON

ONE PERSON'S garbage is another person's . . . electricity?

That's right. Interest in landfill-gas-to-energy projects is booming; currently more than 150 are operating nationwide, providing gas and electricity to almost 200,000 homes.

Now, Houston-based Eco-Gas is developing a methane-recovery system for the largest landfill in the country: Fresh Kills in Staten Island, New York. The system will capture nearly 100 percent of the carbon dioxide and methane that would otherwise be burped into the atmosphere and provide enough power to heat 64,000 homes. In terms of removing carbon dioxide, nitrogen oxides, and other toxic gases from the air, that's the equivalent of removing 1.5 million cars from the roads.

The technology behind these systems is simple. Once the landfill is capped, a vacuum sucks landfill gases—predominantly carbon dioxide and methane—into a recovery plant where they are first washed with water to eliminate large particles. The gases are compressed and cooled to remove the water before being transferred to another chamber that extracts the malodorous compounds. The cleaned gas is funneled into a series of chambers containing compounds that bind carbon dioxide molecules. In most existing plants, the carbon dioxide is burned off; in new plants, however, it will likely be liquefied and sold to make dry ice and other industrial substances. The pure methane can be sold to utility companies or pumped directly to homes.

Along with environmental benefits, these systems save communities money. A recovery plant in Prince George's County, Maryland, that supplies heat and electricity to a nearby correctional facility, for example, will save taxpayers more than $10 million over the next 10 years.

How long will the trend continue? That will depend on the government's commitment to environmentally friendly technologies, says the EPA's Shelly Cohen. In 1992, when the Clinton Administration began offering incentives to companies generating energy from renewable sources, interest boomed. But, Cohen says, these incentives are due to expire in 2007.—*Gunjan Sinha*

HOME OFFICES

Light Wires

FEELING UNINSPIRED lately? It could be your lighting. Studies show human productivity plummets when there's a dearth of natural light. That doesn't bode well for telecommuters working in basements or other dark spaces that can't accommodate a skylight.

But a "daylighting" system now in development could change all that. With funding from the Department of Energy's Small Business Innovation Research program, Steven Winter Associates—an architectural firm in Norwalk, Connecticut—is designing a system that will concentrate daylight on the roof and then send it through a fiber-optic line that can be snaked through floors and walls as easily as electric or phone lines. The fibers will deliver the natural light—enough for a 250-square-foot room during the day—to a ceiling-mounted diffuser that looks like a standard light fixture.

The daylighting system is a first for the residential market. Laforet Engineering, a Tokyo, Japan-based firm, makes a commercial system, but it requires an unsightly roof-mounted tracking device as well as a computer controller. And the price to deliver the same amount of light as a 75-watt bulb is around $3,000.

According to Z Smith, a researcher with Steven Winter Associates, the new residential system will overcome these issues. It will have no moving parts, consume no electricity, and be much more affordable. At $10 per yard, the plastic-fiber wiring in the new system is 20 times less expensive than the glass-fiber wiring in Laforet's system. Also, the collector will look like standard roofing material.

The daylighting system should hit the market in about two years, at a price of about $500.—*Charles Wardell*

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HOMEBUILDING

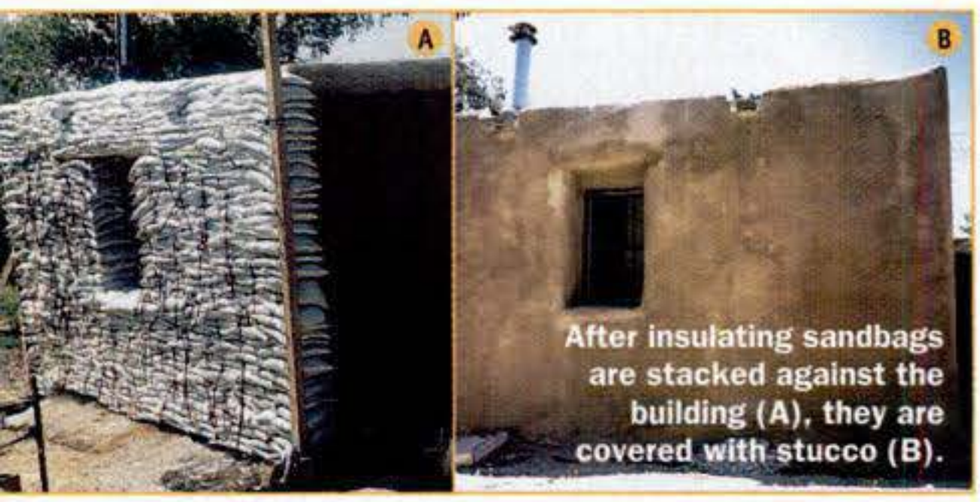
To Build It, Bag It

IT SOUNDS almost too good to be true: a low-cost siding that insulates better than conventional siding, does not attract termites, and is made from recycled materials indigenous to the local area. That's the Vohra Wall, the brainchild of U.S. Department of Energy engineer Arun Vohra. And though it won't garner any architectural design awards, it could signal a better way to build low-cost housing.

The siding consists of sandbags filled with an insulating material stacked against the outside of an existing building (or between the members of a post-and-beam frame). The surface is finished with wire mesh and stucco.

The inexpensive system is self-supporting, requires no foundation, and uses just a few pieces of lumber at the corners. And while the price of a conventional exterior insulation and finish system ranges from $5 to $12 per square foot for an insulation value of R-8, Vohra's wall gets a rating of R-16 for $3.76 per square foot. Vohra expects costs to drop further.

One drawback: The finished wall is about 18 inches thick, leaving deep window wells that could darken a home's interior. But Vohra says this problem can be prevented by tapering the wells.—*C.W.*



After insulating sandbags are stacked against the building (A), they are covered with stucco (B).

MAINTENANCE

The Home Checkup

THE CALIFORNIA–EL NIÑO faceoff may have grabbed the headlines, but 27 other states had unusually wet winters this year as well. The result? Water damage, and lots of it, says the American Society of Home Inspectors (ASHI) in Arlington Heights, Illinois.

That's no small—or inexpensive—problem. Even before this winter, ASHI says, more than 40 percent of U.S. homes suffered from a water-related malady. The most frequent? Improper surface grading, which leads to water in basements and crawlspaces.

Now's the time to find out if El Niño left its calling card on your doorstep. ASHI recommends that you hire a certified home inspector to give your home the once-over; if you can't do that, check out these six areas for yourself:

ROOFING. Look for damaged, loose, or missing shingles and flashing. Also inspect the attic and ceilings for water damage.

GUTTERS. Look for leaking, misaligned, or damaged gutters. Also check for blockages.

BASEMENTS. Look for water accumulation or moisture in cellars and crawlspaces.

FLOOR TILES. Loose tiles signal water damage. Not sure if one is loose? Tap it with a cloth-covered hammer or wrench. If you hear a hollow sound, the tile is loose.

CARPETS. Moisture on or under a carpet, or rusting metal carpet strips, signals water.

DOORS AND WINDOWS. At each entry in the home, check for sealing problems with caulking and weatherstripping.—*W.G.P.*

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AUTOMOTIVE

EDITED BY DAN McCOSH

TECHNOLOGY

Fuel-Saving Combo

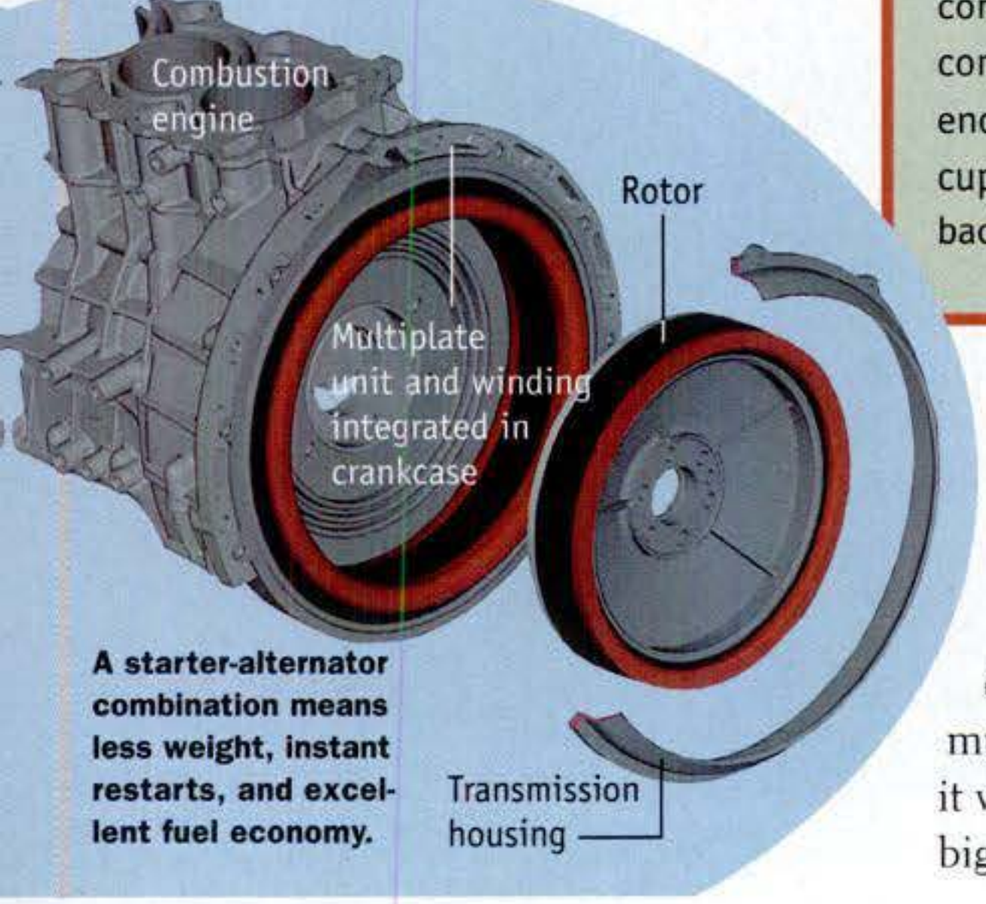
AN OLD IDEA is getting a jump start at BMW and Citroën. The concept, combining the starter and alternator into a single unit, would offer serious gains in fuel economy.

While both companies' approaches are similar, BMW has released the most specific details. In its concept, the starter motor with associated gearing and the belt-driven alternator would be replaced by a single-induction motor integrated with the engine. The 12-inch stator would fit on the crankcase, with the rotor bolted to the crankshaft acting as the flywheel.

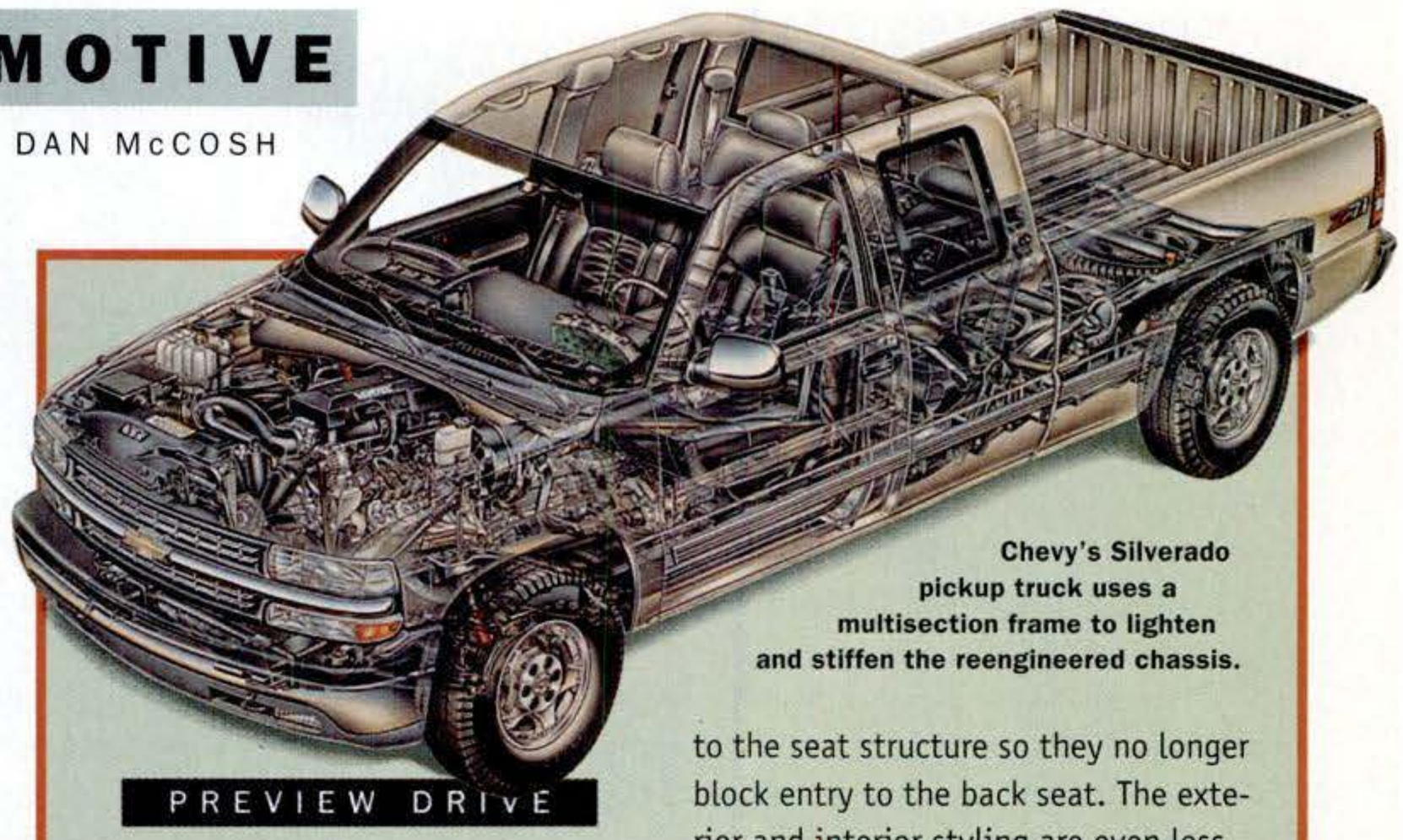
The vehicle would have two batteries, a 12-volt for lights and accessories and a huge 36-volt to power the starting motor. That battery would deliver a hefty 295 foot-pounds of torque to spin the engine directly, without gearing, at 500 rpm for starting, rather than the normal 60 rpm produced by a typical starter motor. At this cranking speed, the engine fires instantly, reducing emissions. Such speed also allows the engine to run in an automatic start-stop mode as an initial economic benefit, and eliminates emissions at traffic stops.

Although the battery could deliver such massive electrical muscle only in short starting bursts, it would then be recharged by the big alternator to have a surplus of power available for other tasks.

To gain further fuel savings, all engine-driven power-consuming auxiliaries would be scrapped. Steering would be electric, with power added for parking. The air-conditioning compressor, engine water pump, and brakes would also be electrically driven.—*David Scott*



A starter-alternator combination means less weight, instant restarts, and excellent fuel economy.



Chevy's Silverado pickup truck uses a multisection frame to lighten and stiffen the reengineered chassis.

PREVIEW DRIVE

A Decade's Worth of Change

THE 1999 SILVERADO, the first reengineered Chevrolet full-size pickup in more than a decade, brings a wealth of improvements. The new chassis and powertrain is, by sheer numbers, the largest platform change GM has ever attempted, and eventually will provide the underpinnings of its full-size pickups and sport-utilities.

The new truck offers three slightly downsized V8 engines, redesigned to improve fuel economy; four-wheel disc brakes; a multiplexed electrical system; and (in light-duty editions) rack-and-pinion steering.

Brief drives in two prototypes revealed a much stouter frame and cab construction. The extended cab now comes with three doors standard and enough interior room to give rear occupants more legroom and a reclined backrest. Front seatbelts attach directly to the seat structure so they no longer block entry to the back seat. The exterior and interior styling are even less adventurous than that of the GMC Sierra, which shares the same new platform.

The new rack-and-pinion steering is quicker and more responsive. Unfortunately, a 1.5-inch increase in wheelbase stretches the turn-circle diameter to more than 40 feet. The spongy brakes that plagued the previous-generation Chevy pickup have been replaced by a firm pedal that delivers reassuring stopping performance with half the effort.

The redesigned Vortec 5300 5.3-liter V8 engine is smooth and quiet, with more horsepower (270 versus 255) than the 5.7-liter V8 it replaces. A new, optional AutoTrac on-demand four-wheel-drive system uses wheel-speed sensors to engage the front axle when rear-wheel slip is detected.

It's doubtful that the new Silverado has the chutzpah to convert faithful Dodge or Ford fans, but it certainly is cause for celebration in the Chevrolet camp. Prices are expected to start at $16,000.—*Don Sherman*

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PREVIEW DRIVE

Quick and Quiet

Sleek and smooth, the new Galant should be a more formidable competitor in the midsize market.

THE MITSUBISHI GALANT has been reengineered for 1999, with a stiffer unibody and a sleek new skin—the coefficient of drag is a mere 0.29. The result? A quieter and smoother vehicle at all speeds. It's also faster, thanks to a 190-horsepower sohc 24-valve V6 engine option, a first for this midsize sedan. The base engine, however, continues to be a 2.4-liter sohc 16-valve four-cylinder that, though refined, is similar in output to its 145-hp predecessor.

The new Galant's dimensions are the same as the previous edition—similar to those of the Honda Accord and Toyota Camry. Mitsubishi decided that this was big enough and, judging by a ride in the back seat, we agree.

A couple of elements are conspicuously absent. The first is a manual transmission—Mitsubishi says there was limited interest in the option. All models, even the sporty-looking GTZ version, come with a four-speed automatic, though Mitsubishi—which was first to offer so-called fuzzy logic engine/transmission controls—has expanded the range of parameters in the system's computer chip to enhance flexibility.

The second missing element is Mitsubishi's new GDI (for gasoline direct injection) system. Lauded in foreign markets for improving fuel efficiency and reducing emissions, the system won't be available here until the sulfur content of U.S. gasoline is reduced, a program still under study.

Nevertheless, the new Galant shapes up as a more able and attractive competitor in a midsize sedan market dominated by the Accord and Camry. Prices are expected to range from $18,000 to $20,000.—*Tony Swan*

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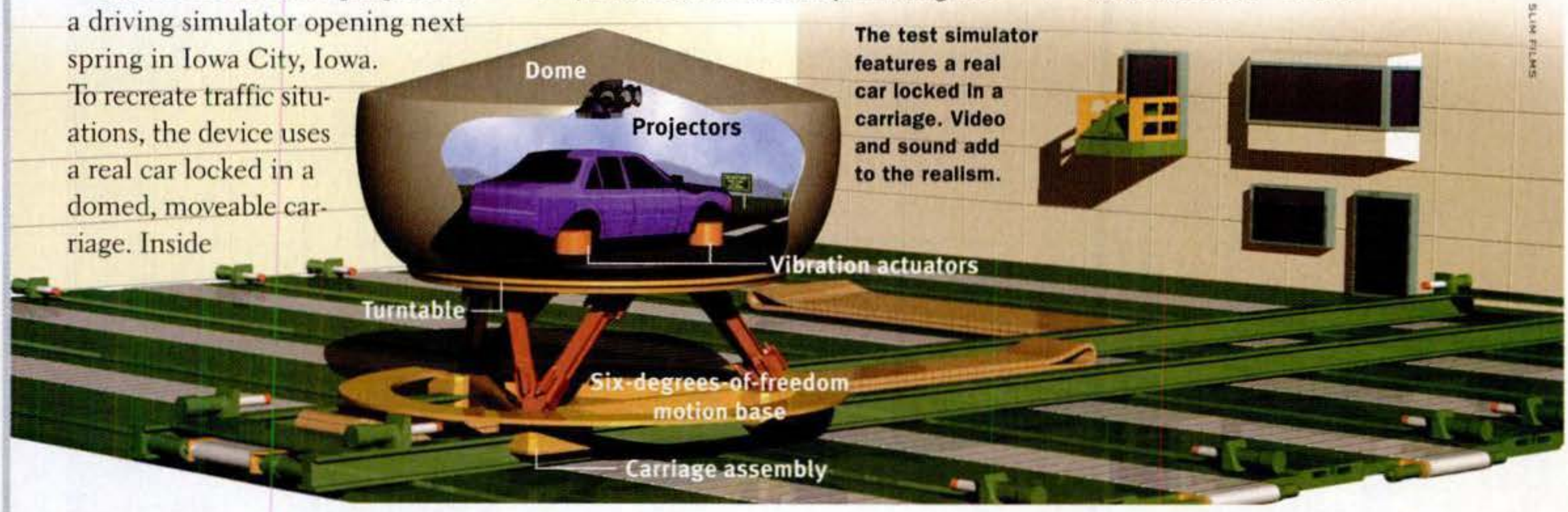
SAFETY

Crash School

HOW DO DRIVERS react when presented with a crisis situation? That's the subject of new research currently being undertaken by the National Highway Traffic Administration.

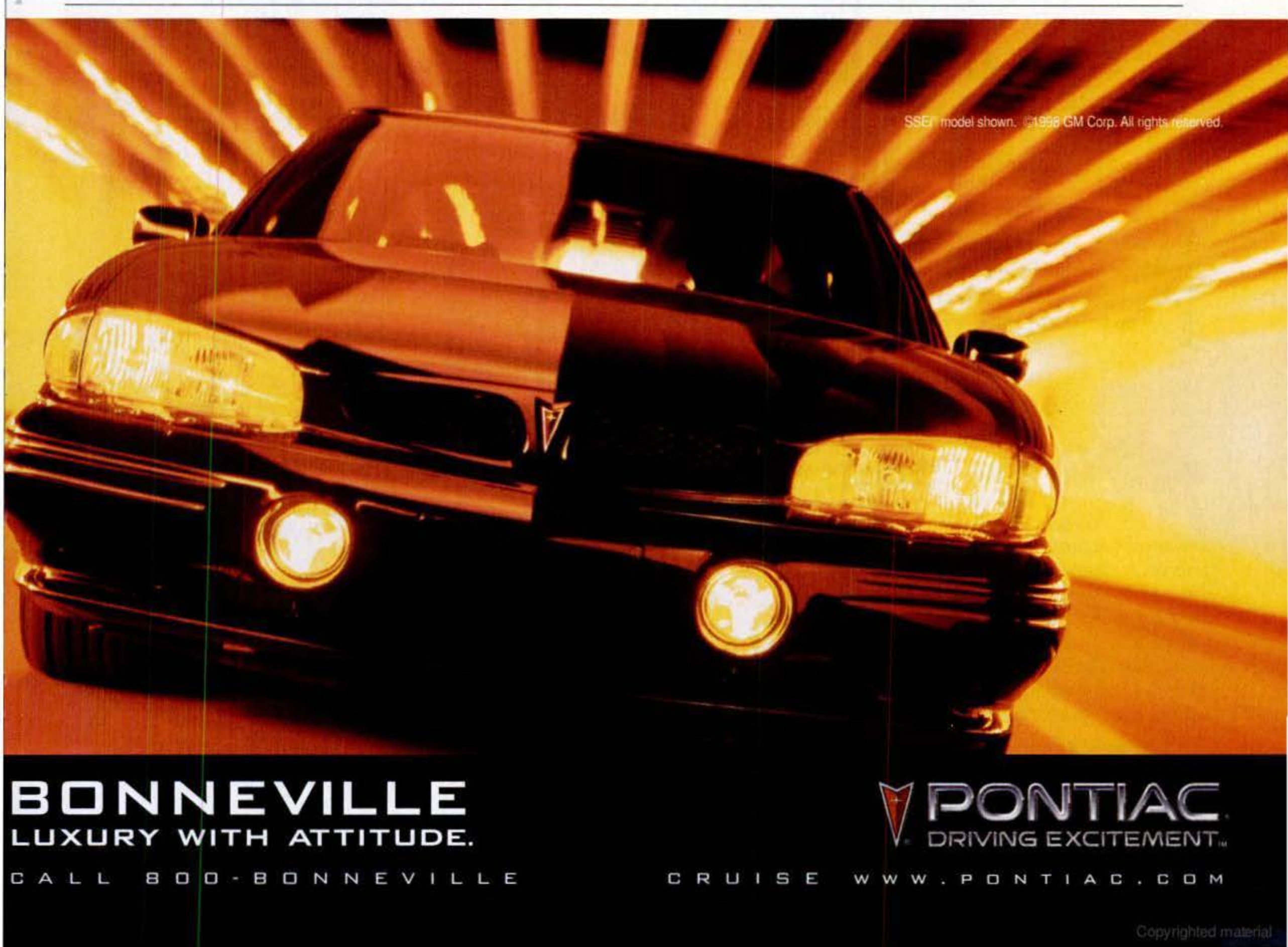
At the heart of the program is a driving simulator opening next spring in Iowa City, Iowa. To recreate traffic situations, the device uses a real car locked in a domed, moveable carriage. Inside the simulator, surround sound audio and a high-quality video-projection system add realism. The track-mounted carriage can move on three axes and produce 1-g acceleration in most directions, enough to give the sensation of a sudden accident-avoidance maneuver.

Driver response has been the subject of debate recently. Among the controversies: differing opinions on how the average driver uses the antilock braking system and the effect of this response on accident avoidance; and how a driver handles sudden evasive maneuvers that could lead to a rollover. The simulator will also be used to study the effects of drugs, prosthetics, and aging on driver reflexes.—*D.M.*



The test simulator features a real car locked in a carriage. Video and sound add to the realism.

SLIM FILMS



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SAFETY

Blind Speed

DRIVERS HATE FOG—it slows them down. Or so they think.

As people with poor eyesight can attest, a blurry world seems to move in slow motion. Now, research conducted in a virtual reality environment confirms the fact that fog indeed alters the perception of speed, duping drivers into thinking they are traveling more slowly than they really are. The consequence is that drivers then often speed up, at their own hazard.

Robert Snowden and his colleagues from the School of Psychology at the University of Wales, in Cardiff, placed testees in a virtual reality driving simulator, where they were asked to travel at a specific speed under both foggy and clear conditions—without a speedometer. On average, drivers drove 10 miles per hour faster in the fog. Another test exposed drivers to foggy and clear conditions simultaneously; they were then asked to log the point at which both scenes appeared to be moving at the same speed. Overwhelmingly, the test subjects perceived the foggy scene to be moving more slowly.

Previous studies have suggested that decreasing levels of contrast in a person's field of vision can distort the perception of speed, and future research will try to confirm these studies. In the meantime, the next time you hit some highway fog, you might be wise to keep a close eye on the speedometer.—*Gunjan Sinha*

PREVIEW DRIVE

Sidekick No More

THE 1999 SUZUKI VITARA is the natural successor to the Suzuki Sidekick, which is now sold only by Chevrolet as the Tracker.

Size and body styles (soft-top two-door, conventional four-door) are unchanged, but practically everything else is new or improved. The standard engine is a new dohc 16-valve 2.0-liter four-cylinder rated at 121 horsepower. Four-door models, called Grand Vitaras, are powered by a dohc 24-valve 2.5-liter engine that delivers 140 horsepower.

Our first drive in the Grand Vitara revealed that past Suzukis' buzzy sluggishness is gone. This cute ute accelerates smartly into the passing lane and hums smoothly to a 6,500-rpm redline. The V6 has enough torque to tow a small boat or tote a load of camping gear. Wide 16-inch radial tires provide 8 inches of ground clearance. A full-size spare is mounted lower on the hinged rear door to minimize vision blockage. Also, the new four-wheel-drive transfer case can be engaged on the roll. In addition, the Grand

The renamed Grand Vitara eradicates past Suzukis' sluggishness.

Vitara feels much more stable at highway speeds than previous Suzukis, thanks to a more sophisticated suspension design.

Prices aren't set yet, but a loaded Grand Vitara should cost around $20,000.—*Don Sherman*

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ELECTRONICS

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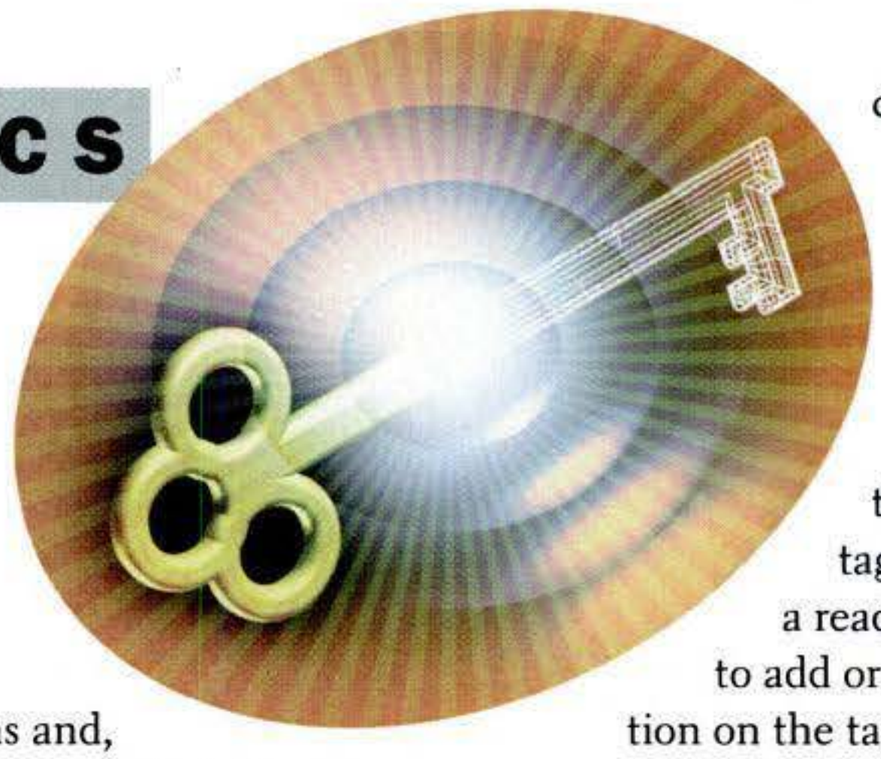


TOM WHITE

SECURITY

Radio ID

BAR CODES AND magnetic strips blend seamlessly into our daily lives—until we have a problem with one, that is. These identification devices show up everywhere—from the grocery store and ATM machine to the post office—but they're subject to the effects of dirt and wear.

A new technology overcomes these disadvantages. Radio frequency identification (RFID) is impervious to dirt and other obstructions and, perhaps more important, it can be read from a distance and through boxes and other packaging.

RFID comes in two flavors: active and passive. Operating with an internal battery, active RFID tags—such as those used in automated toll collections—give off a radio signal that includes specific information. A reader or transceiver picks up and decodes the signal. Active tags can also include a read/write function to add or change information on the tag.

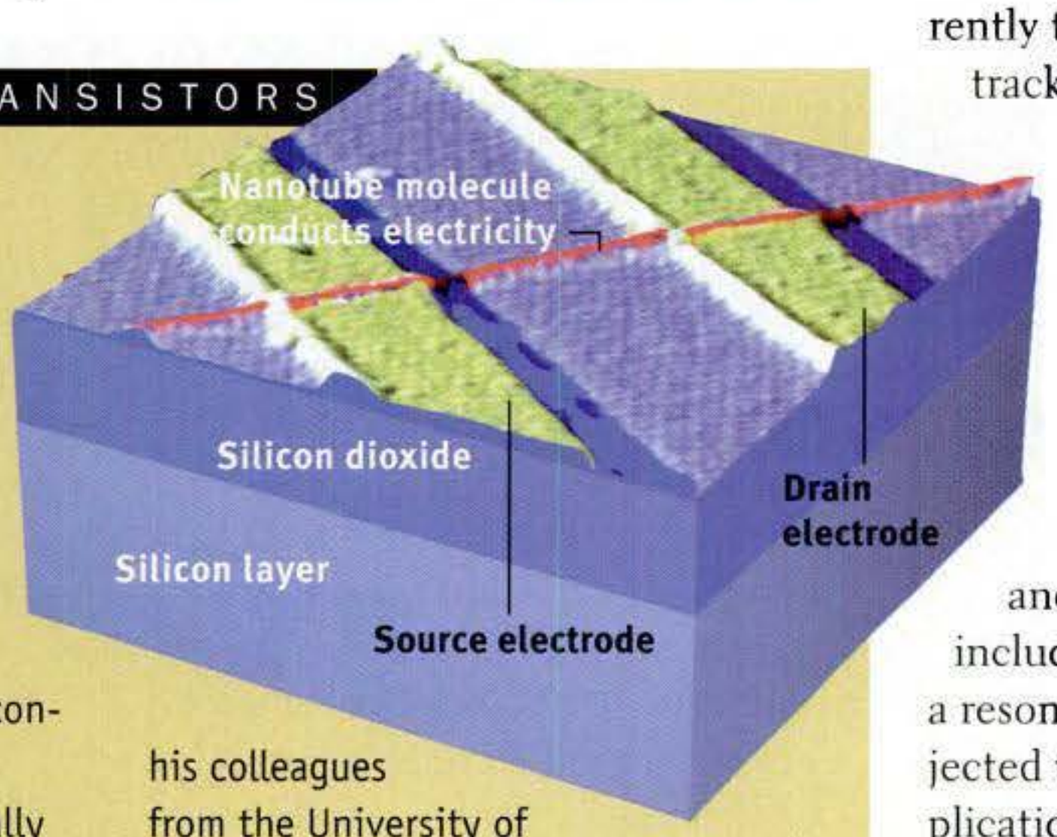
Passive tags, meanwhile, such as those used in antitheft devices you walk through at the video store, contain no batteries. Instead, they respond to or alter radio signals that are sent out by another device.

The U.S Postal Service is currently testing RFID technology for tracking bottlenecks in mail delivery, and it's gaining acceptance for tagging items like laptops and cellphones and for a host of other security applications. Inkode of Vienna, Virginia, has developed a system that incorporates passive RFID into paper and inks. The product, which includes quartz crystals, gives off a resonant signature when subjected to low-level radio waves. Applications for the technology will include not only authentication of such documents as payroll checks, but internal security as well. The company is developing an RF thread that will allow manufacturers to sew—literally—serial numbers into clothing to combat fraud.

Texas Instruments has introduced the Tag-It system, paper-thin RF-based "smart labels" that can be used in everything from baggage handling and parcel-delivery tracking to ticketing and anticounterfeiting. Another company, Mikohn of Las Vegas, has developed a blackjack system that employs RF chips to help casinos track the action at the tables. And when the house puts its money on RF, it must be a sure thing.—*Hank Schlesinger*

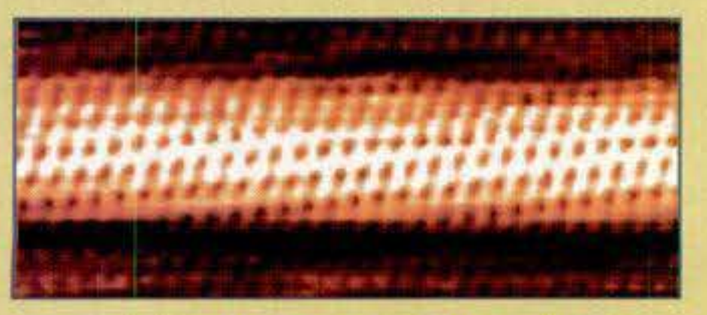
TRANSISTORS

The Tiniest Circuit



THE 21ST CENTURY may finally usher in electronic devices and computers no larger than a push-pin. A rush of recent research with carbon nanotubes—rolled sheets of carbon just 1/50,000 the thickness of a human hair—has shown them to be excellent conductors of electricity.

A carbon nanotube is essentially vaporized carbon condensed into a series of hexagons. The hexagons naturally curl into hollow tubes; the electronic properties of each tube depend on its twist. If the carbon sheet forming a nanotube is rolled up evenly, the molecule conducts electricity as if it were a metal. But if the sheet rolls up at a twisted angle, the nanotube behaves like a semiconductor.



A single nanotube molecule like this one can conduct electricity.

Last year, researcher Alex Zettl and his colleagues from the University of California at Berkeley showed that when two nanotubes slightly dissimilar in size are joined together end to end, their junction functions as an electronic device called a diode—the basis of devices used to convert alternating current into direct current.

Recently, scientists from Delft University of Technology in the Netherlands built a tiny transistor consisting of a single carbon nanotube lying across two metallic contacts that sit on a layer of silicon dioxide (above). Nano-transistors have been built before, but this is the first time one has operated at room temperature as a semiconductor. The next step is to see if nano-transistors can be built into electrical circuits.—*Gunjan Sinha*

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DIGITAL TV

The Cost of Clarity

WHEN DIGITAL TVs arrive this fall, prices of $4,000 and higher will probably keep most people from rushing out to their local electronics store. Instead, many will likely explore a less expensive option—a set-top box that receives digital signals on existing analog or DTV-compatible sets.

It now appears, however, that these boxes won't sell at bargain-basement prices either. Mitsubishi is planning to market its set-top HD-1080 receiver for about $3,000. Panasonic will do a little better: Its TU-DST50 set-top box should cost about $1,700, a price made possible by the development of a single chip that will decode all the digital TV formats. The least expensive decoder will probably be RCA's $700 DTC-100.

So what's inside the box? In addition to the digital TV decoder, these boxes—which are about the size of a VCR—include Dolby Digital surround sound circuitry. They also have a host of analog and digital connections. Panasonic's model, for example, employs a 1394 digital connector, which is the link to the sub-$1,000 Digital VHS VCR (model PV-HD1000) that the company will introduce this fall for recording DTV programs.—*F.V.*

Digital TV decoders will be pricey, as evidenced by Mitsubishi's $3,000 HD-1080 (above) and this $1,700 Panasonic model.

MATERIALS

Smart Structures

BECAUSE OF their strength and light weight, carbon composite materials are already used to make airplane and car parts, bridges, bicycle wheels, and other products. Now a scientist has discovered that carbon composites have electrical capabilities as well. The discovery could open the door to a new class of electronic devices made from structural materials instead of computer chips.

Deborah Chung, an engineering professor at the State University of New York at Buffalo, made the discovery while studying the electrical behavior of carbon composites for a way to improve damage detection. She showed that she could detect temperature changes using the material itself, rather than an attached sensor. This capability could enable a machine to tell its operator when and where it is overheating.

While studying the composite material, which consists of layers of carbon fibers embedded in a polymer matrix, Chung noticed that, like semiconductors, its electrical properties changed with temperature.

The next step is to use the material's newfound properties to create electronic devices. One likely application is in aircraft, which already contain many carbon composite components. Engineers could eliminate conventional damage sensors now embedded in aircraft parts.

Semiconducting carbon composites would be easier and less expensive to manufacture than traditional silicon-based electronics. The disadvantage of a structural semiconductor, according to Chung, is that it doesn't lend itself to miniaturization. It is unlikely then that you'll see carbon composites used in such devices as high-speed computers, although the large surface area of structural semiconductors makes them good at heat dissipation.—*Dawn Stover*

COMMUNICATIONS

Transmitting Chaos

THE BEST WAY to get from point A to point B may not be a straight line, according to researchers at the University of California at San Diego. USCD's Institute for Nonlinear Science is working on a way to use chaotic signals to send wireless communications.

Communications systems today are designed to keep signals as linear as possible, without any distortions—the static you hear on analog cellular and cordless phones, the pops on digital systems. To accomplish this, the signal has to have a lot of power behind it. A chaotic signal is not subject to distortion and thus requires less power.

The tagging and decoding principles of a chaotic signal system are similar to those used for an AM/FM radio. The radio wave's height is altered to carry the sound information for AM, and the width of the wave changes for FM radio. A chaotic signal doesn't stick to either frequency or amplitude modulation—it's unpredictable.

In the UCSD's proposed system, the sender would attach his message to a chaotic signal, and the combined signal would then be transmitted over a wireless network. The receiver synchronizes with the sender, then subtracts the message from the combined signal. With perfect synchronization between the sender and receiver, no distortion occurs.

The unpredictable nature of chaotic signals makes them more secure than linear systems. When an eavesdropper tries to listen in on a linear-signal conversation, he or she picks up a certain amount of information, then waits until it repeats. By targeting that recurring pattern, the eavesdropper can intercept the signal. The absence of patterns in chaotic systems makes the signal secure.—*Suzanne Kantra Kirschner*

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Hy "Dude" Tide

Career: Accountant
Passion: Catching waves
Watch: Casio Marine Gear (MTD1010A-2A)

Bill Ding

Career: Construction Foreman
Passion: Snorkeling
atch: Casio Marine Gear (DW285G-1V)

Sal Manella

Career: Sous Chef
Passion: Water Skiing
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Missing in Action

Heavily damaged on final approach to Koh Tang, one of the 13 helicopters instead b made an emergency landing on the coast of Thailand to off-load Marines.

ILLUSTRATION BY TOM WHITE

PHOTOS COURTESY U.S. AIR FORCE
DAVID W. GREER (INSET)

DNA tests reveal the fate of soldiers left behind in the last battle of the Vietnam War.

By Ralph Wetterhahn

THE FINAL NAME INSCRIBED on the Vietnam Veterans Memorial in Washington, D.C., is that of Richard Vandegeer. The "V" in Vandegeer placed the 27-year-old Air Force lieutenant at the bottom of the casualty list for May 15, 1975, the date of the official end to U.S. involvement in the Southeast Asian conflict. Vandegeer's name follows that of 17 other servicemen lost on the shores of an obscure Cambodian island called Koh Tang during the final battle of the war.

For more than two decades, Vandegeer's remains lay trapped inside the sunken hulk of a Sikorsky HH-53 helicopter, which he was copiloting when it was shot down off the island's east beach. Recently, U.S. investigators have been permitted to retrieve the remains from the helicopter and from surrounding sites on the island. Using a relatively new technique called mitochondrial DNA analysis, which compares the genetic makeup of recovered bone fragments with that of blood or tissue samples taken from the living relatives of missing servicemen, technicians have been able to begin putting names to the remains of the soldiers who lost their lives in the battle of Koh Tang.

Although the investigation and analysis have confirmed the fate of Vandegeer, they have raised new questions about other soldiers lost in the battle. It now appears that as many as four men may have been unintentionally left behind—and very much alive—on Koh Tang when the American forces withdrew from the island.

What became of these men? Even after 23 years, it is not too late for scientists to find an answer to this question. In fact, the new technology is making it easier than ever to identify our Vietnam War dead, and to learn the fate of at least some of the 2,089 American soldiers who are still listed as missing in action in Koh Tang and elsewhere in Southeast Asia. And in the future, it may be possible to identify virtually every American soldier who dies in battle.

The 1975 battle of Koh Tang was part of an international crisis known as the Mayaguez Incident. The SS *Mayaguez*, a merchant ship carrying 274 large containers, was plying the seas in international waters off Cambodia on May 12, 1975, when it was hijacked by Khmer Rouge naval forces. For three days, the *Mayaguez* and the plight of its crew of 40 merchant seamen captured the attention of the world. Then, after intense negotiations between Washington and Phnom Penh failed, President Ford ordered a military rescue operation.

A ship-seizure team from the *USS Harold E. Holt*, a destroyer escort, assaulted the *Mayaguez*. Marines boarded the ship, found it abandoned, and took con-

Staff Sgt. Jon D. Harston and Maj. Howard A. Corson (in flight suit) were wounded in the battle, and their helicopter, Knife-31, was shot down. Harston received the Air Force Cross for exceptional heroism.

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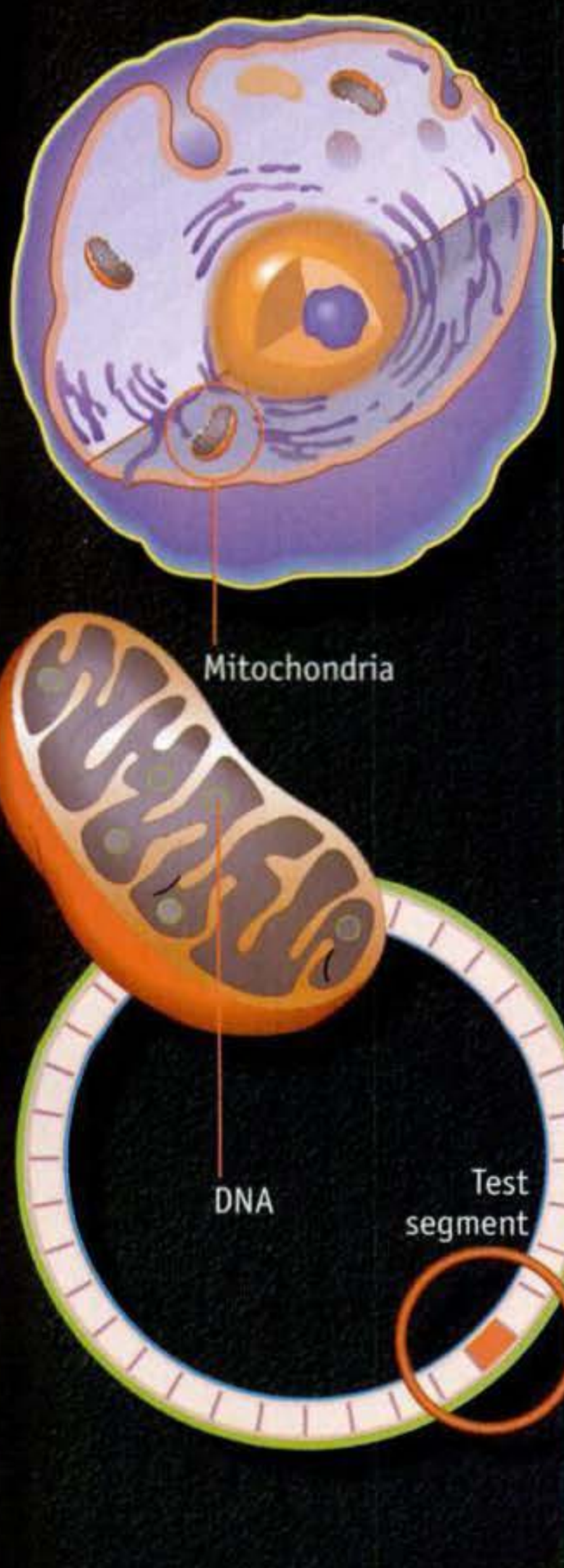
Whose Bones Are They?

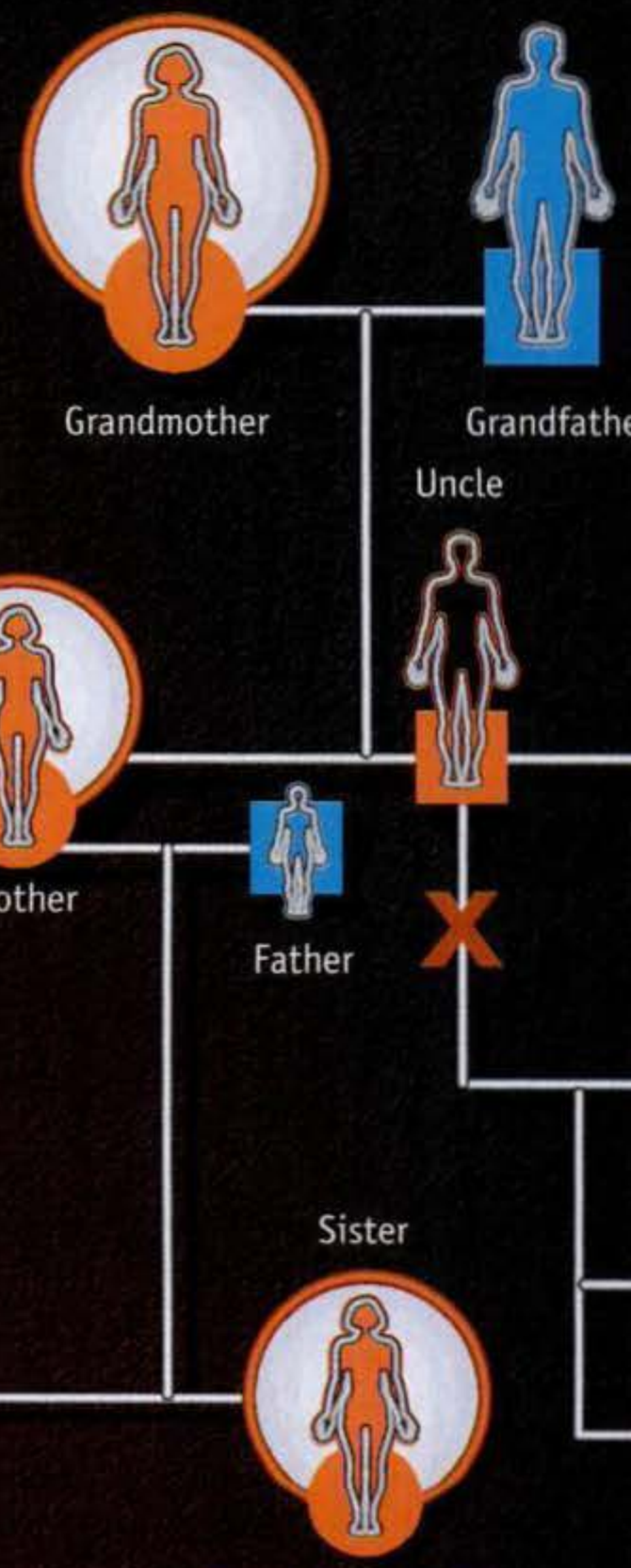
TO IDENTIFY recovered bones, DNA extracted from them is compared with DNA taken from the relatives of missing soldiers.

The Unknown Bone

The first step in identifying a recovered bone is to extract a sample of DNA from it. In decades-old bones, the only surviving DNA is found within the mitochondria, the energy-producing components of the cells. A segment of the DNA is snipped out for analysis.



Like everyone else, a soldier inherits his mitochondrial DNA from his mother.

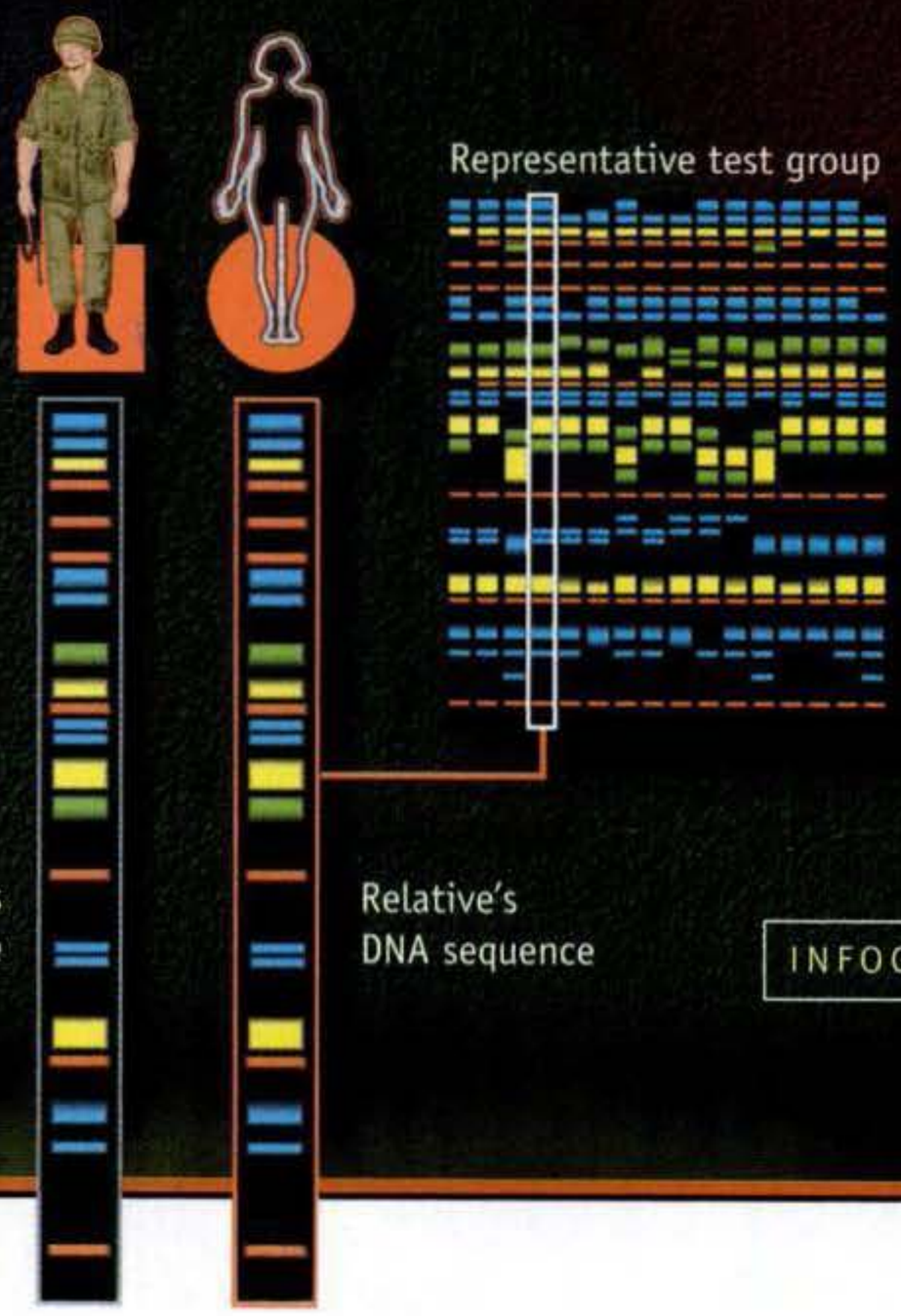


The Family Tree

DNA is extracted from blood samples provided by maternal relatives of the missing soldier—his mother, grandmother, sister, and two uncles in this example. The relatives' DNA samples are then compared with the DNA taken from the unidentified bone.

Making a Match

Nucleotides in the DNA are color-coded, making it easy to compare the sequences of many people. In this example, the sequence from the bone matches the sequence from a relative of the missing soldier, so it is likely that the bone belongs to that soldier.



INFOGRAPHIC BY MATT ZANG

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Cracking the Code

TO ANALYZE THE MITOCHONDRIAL DNA in human remains, lab technicians first cut off a fragment of a bone. They sand and wash it to remove bacteria and other contaminants. Then they break the specimen into smaller pieces with a hammer and chisel, and place the pieces in a blender to pulverize them into a fine dust. Next, they place the dust in a chemical bath that breaks open the bone cells, releasing strands of DNA. The technicians then use a centrifuge to separate the DNA from cell debris.

The mitochondrial DNA strands are made up of thousands of pairs called nucleotides. There are four types of nucleotides: adenosine (A), thymidine (T), guanosine (G), and cytidine (C). When these nucleotides bond to form pairs, they always do so in a predictable fashion: A with T, G with C.

Each pair of nucleotides forms a rung of the mitochondrial DNA in an immensely long spiral ladder. The seemingly random sequence in which the nucleotide pairs are arranged is actually a code that identifies individuals who are maternally related.

To crack a person's code, the technicians need to figure out the correct sequence of nucleotides. They do this by exposing the DNA taken from the bone to a series of chemical reactions inside a test tube. They first mix the DNA with unattached nucleotides, some tagged with phosphorescent colors (A is green, T is red, C is blue, and G is yellow).

The test tube is then placed into a machine that periodically heats it, to split the double-stranded DNA into single strands. A special enzyme attaches itself to each single strand of DNA and rebuilds a matching strand of DNA by grabbing onto single nucleotides floating in the mixture, some of which are colored. This process, called a Polymerase Chain Reaction, is repeated many times to make many identical copies of the original DNA sequence, creating a large DNA sample that is easier for the technicians to study.

Using a laser to "read" the colors, the technician can determine the sequence in which the nucleotide pairs are arranged in the reconstructed DNA. The sequence of colors is compared with those of a soldier's maternal relatives: grandmother, mother, great-aunts and -uncles on the grandmother's side, maternal aunts and uncles, siblings, children of sisters, and so forth. If it matches, the probability that the bone came from that particular soldier is high.—*R.W.*

trol. Simultaneously, a helicopter assault on nearby Koh Tang's two small beaches was launched in an effort to free the crew thought to be held there.

On the morning of May 15, 1975, as survivors of the battle recall, 22 Marines and two Navy medical corpsmen sat in webbed seats facing one another inside a Sikorsky HH-53 helicopter with the call sign Knife-31. Up in the cockpit, Lt. Vandegeer peered through the Plexiglas at a molten sun boiling up out of the sea to the east. Because hostages were involved, a night attack had been ruled out. Finally the order came, and the pilot, Maj. Howard A. Corson, nosed the big twin-engine helicopter over to begin the attack on the small, eastern beach of Koh Tang. To the defenders, the assault would come as no surprise.

The crew from the *Mayaguez* were supposedly being held hostage in a compound just behind the beach, according to reports from American surveillance aircraft. Only 20 defenders were expected, not the 150 heavily armed Khmer Rouge that actually lay in wait. The Marines inside the helicopter gripped their weapons, nerves stretched taut, like thousands of leathernecks had so many times before, off so many foreign shores. They watched anxiously as Sgt. Randy Hoffmaster stood spread-legged at his cabin gun port, swiveling his minigun sight onto the beach. This was it.

Suddenly, flaming tracers crisscrossed the sea. Something slammed into the helicopter as it came to a hover just offshore. A tank on the left side of the helicopter exploded from a direct hit by a rocket-propelled grenade. Flames appeared above the porthole. Up front, Corson tried vainly to reverse course. As the chopper swung away, Hoffmaster returned fire with his minigun. Vandegeer grabbed an M-16 and began shooting from his open cockpit window as fire burst through the cabin sidewall. Another grenade hit blew away the instrument panel and filled the cockpit with smoke. The helicopter dropped into the water like a wounded duck.

Inside, the men unstrapped and attempted to douse the flames. Ammunition began exploding in the intense heat. Then the helicopter's magnesium rotor head caught fire. A Marine punched at a window until a crewman appeared from the submerged forward hatch to lead some of the dazed Marines out. Three rushed toward shore, firing as they splashed through waist-deep water. All three fell forward into the bullet-churned surf. Others swam seaward to eventual rescue by one of two American ships in the area. Vandegeer was among the 13 men aboard the helicopter who never made it to safety that day.

Meanwhile, a second helicopter was destroyed as it landed nearby; the 25 men aboard scrambled for the tree line. On the island's west beach, just a short distance away, additional helicopters successfully disembarked the bulk of the American forces.

As it turned out, the crew of the *Mayaguez* was no longer on Koh Tang when the fighting began. As the Marines were landing on the island, the hostages had

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already been released and were boarding a fishing trawler docked at another island, where they had been taken by their captors for the night. The trawler was quickly spotted as it made its way toward the *Mayaguez*, and the guided-missile destroyer *USS Henry B. Wilson* moved to recover the crew. Then began the arduous task of withdrawing U.S. ground forces from the heavily defended island.

For 14 hours, the Americans lay pinned down on Koh Tang's two small beaches. Finally, after dark, the last of the total force of 231 marines, sailors, and airmen who had landed on the island were withdrawn by helicopters in one of the most dramatic wartime rescues ever conducted. By the time the mission was over, three HH-53 helicopters had been shot down, six received severe damage, three others were heavily damaged, and only one was still flyable. Eighteen men were unaccounted for, at least three of whom were known to be alive late in the day.

The families of some of those men are still seeking answers about exactly what happened during the final hours of the intense battle. A few facts are beginning to emerge from the Joint Task Force–Full Accounting, a group of military investigators that has returned to Koh Tang three times over the past three years. Braving storms, unexploded ordnance, poisonous snakes, and malaria, the search team members have made some startling discoveries. Twice I have accompanied the group to help with the search efforts.

After landing by helicopter on Koh Tang that first time in November 1995, I felt I had taken a step back in time. Ringing both beaches were the old fortifications, machine gun pits, bunkers, and trenches—all overgrown but basically undisturbed. Trees were pocked with bullet holes, and daylight shone through a 6-inch hole in the trunk of a palm tree that had survived the battle.

Just off the island's east beach, a rotor head from a downed helicopter jutted from the surf at low tide. Further south, what was left of Corson's helicopter, Knife-31, and its unfortunate human cargo lay under gentle swells that lapped the shore. A half mile to sea near a reef, the twin engines of a sunken Khmer Rouge patrol boat were lying side-by-side on the bottom. On the west beach, corroded AK-47 shell cases lay on the ground in front of a bunker. In shallow surf near the rocky outcropping a few yards away, an empty M-16 cartridge was buried in wet sand. You could almost hear the echo of machine gun rounds pinging off the rocks.

The task force team used block and tackle to pull pieces of Knife-31 to the beach. One section of the tail ramp was hauled ashore only to burst into flames a short time later. "Over the years, phosphorus had leaked from a mortar round onto the ramp," explained Army Master Sgt. Robert Maves. "When the stuff dried, it mixed with oxygen, and we had spontaneous combustion." After 20 years, the hulk of Knife-31 was not done burning.

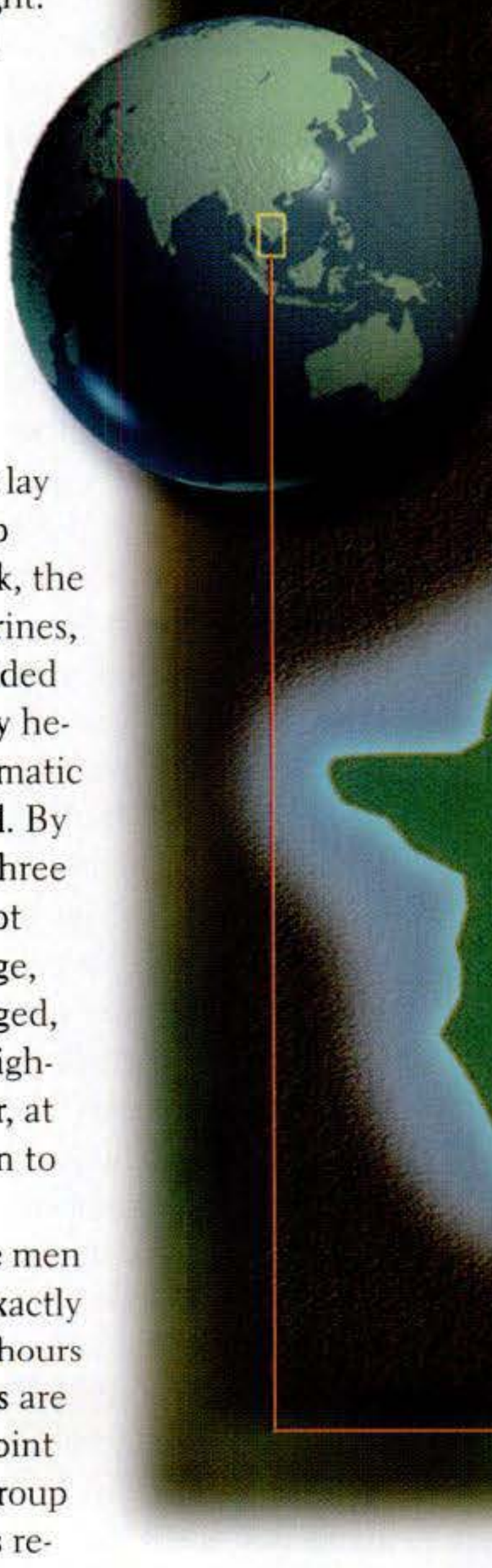
Using suction pumps and an elaborate system of wire screens, the team recovered a total of 161 human bones from inside and beneath the wreckage of Corson's helicopter. Then began the process of identification, an agonizingly thorough procedure in which DNA is extracted from the bone fragments.

DNA "fingerprinting" has been used in a number of

The Last Battle

THE VIETNAM WAR ended on the beaches of Koh Tang, a small Cambodian island.

Where the 18 American soldiers, now presumed dead, were last seen: Ten men were lost when Knife-31 sank off the east beach; three men were shot as they headed for shore; one died in fighting on the west beach; one drowned off the west beach; and the three-man machine gun crew was last seen on the west beach.



MATT ZANG

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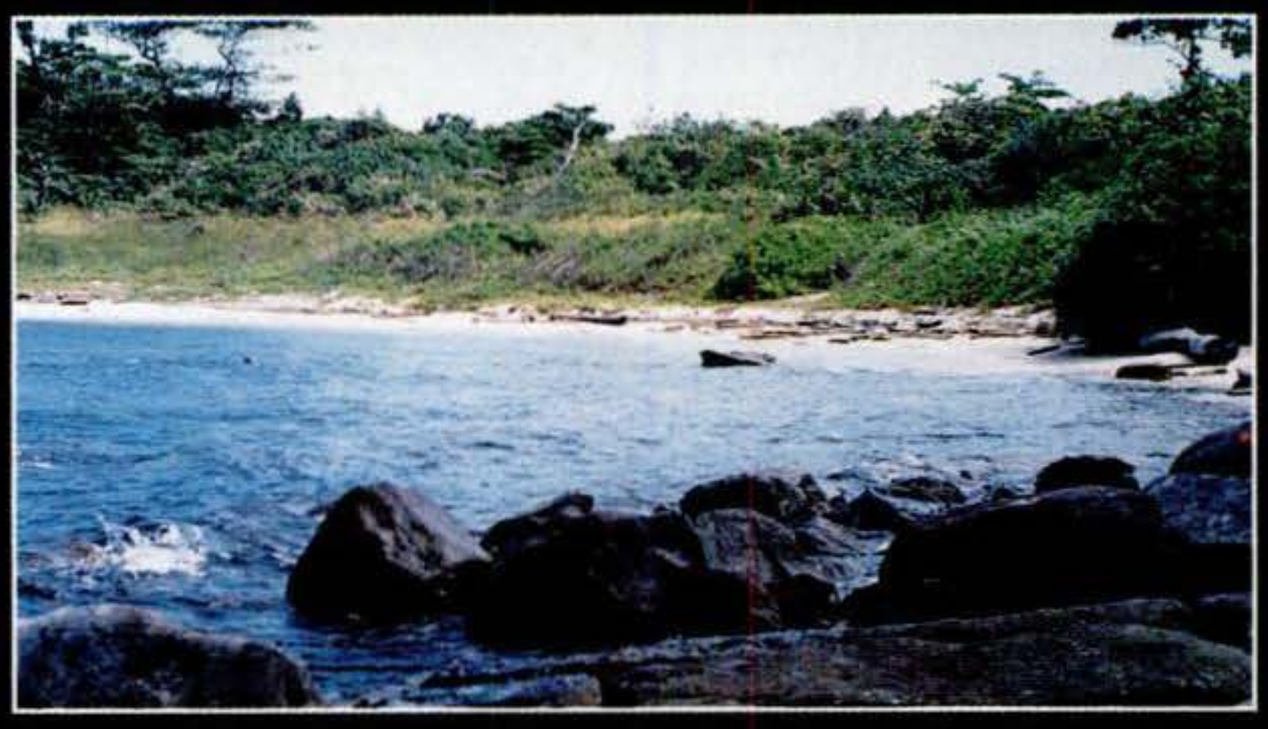

Knife-23 and Knife-31 helicopters went down off the east beach. Boats used for the recovery operation included (at left, from left to right) a barge with four screening tables to sift out bones, a pumper boat, and a diving barge. Wreckage was sorted on the beach. Among the items recovered were a gas mask and M-16 ammo clip (top left). The photo at top right shows the island's west beach, where Khmer Rouge troops tried to swing around a rocky outcropping to flank the Marine forces; they were turned back by American machine gun fire on the beach.

recent court cases, including the O.J. Simpson trial. It can show, for example, that the DNA in a blood sample found at the scene of a crime matches that of a suspect.

Human cells contain two kinds of DNA. The type found in the nucleus, in what are called the chromosomes, is a mixture of DNA from the individual's mother and father. Also inside the cell are hundreds of tiny mitochondria, the cell's energy producers. These contain DNA only from an individual's mother.

"When a living organism dies, DNA inside the cells begins immediately to degrade from the body's own enzymes," explains forensic anthropologist David Rankin of the Army's Central Identification Laboratory in Hawaii, which oversees the analysis of American soldiers' remains. "Then heat, humidity, ultraviolet rays from the sun, and bacteria and other soil contaminants continue the breakdown process."

Each cell has only two copies of chromosomal DNA, and they decay rapidly after death. That makes nuclear DNA analysis impractical for identifying bone fragments that are decades old. The mitochondrial DNA in the bones, however, is much hardier than the nuclear DNA. So one way to identify recovered bones such as those at Koh Tang is to compare the mitochondrial DNA in them with mitochondrial DNA taken from the mothers and maternal relatives of the soldiers missing in action.

Only a handful of laboratories in the world do this type of analysis, and one of them is the Armed Forces DNA Identification Laboratory in Maryland. The lab's primary mission is the identification of deceased servicemen.

To identify the bones found on Koh Tang, the technicians at the lab have been collecting blood samples from as many maternal relatives of the missing soldiers as possible. Only with a large number of samples can the technicians be sure the bones have been correctly identified. That's because the DNA sequences in mitochondria are not as distinctive as those in the chromosomes.

According to Mitch Holland, the lab's resident expert on mitochondrial DNA, "there are probably more than 100,000 different mitochondrial DNA sequences in the

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population, but we won't know until we have more data. Our database is currently 1,200 sequences." Even if the chance of an accidental match were only 1 in 100,000, mitochondrial analysis would still be not nearly as precise as nuclear DNA testing, which can reduce the probability of an accidental match to 1 in millions.

"Mitochondrial DNA analysis is not used as the sole means of identification, because it does not identify an individual, only a blood line," explains Lt. Col. Roger King of the Joint Task Force–Full Accounting. However, when combined with other clues—including wreckage and personal effects found at a crash site, teeth that can be compared with dental records, and bones that indicate a soldier's physical build—mitochondrial DNA matches can be compelling evidence.

The first successful identifications of soldiers' remains using mitochondrial DNA analysis came in 1994. Since then, the technique has been used to show that a woman named Anna Anderson Manahan, who claimed to be the surviving Russian Grand Duchess Anastasia Romanov, was actually a Polish woman of humble origin. Mitochondrial DNA analysis has also helped identify the remains of "disappeared" persons in Argentina, and verify the identity of their kidnapped children, by comparing their DNA with that of living relatives. And mitochondrial DNA analysis is being used to determine the identity of a **Vietnam-era soldier exhumed from the Tomb of the Unknowns at Arlington National Cemetery.**

Meanwhile, DNA analysis may shed new light on what happened at Koh Tang. On the search team's last visit to the island in 1997, I interviewed a former Khmer Rouge medic named Rot Leng. He had been on the island in 1975, and his account of the events of the battle from the Cambodian side were accurate when compared with the American survivors' recollections.

Rot Leng's tale became even more riveting when he dropped this bombshell: "A week after the battle, four Americans surrendered." His description of three of the men matched the members of the machine gun crew seen alive by other Marines shortly before the last helicopter extraction. Lance Cpl. Joseph N. Hargrove, Pfc. Gary L. Hall, and Pvt. Danny G. Marshall apparently stayed in position, defending their unit's flank, only to be left behind during the confusion caused by darkness and intense combat. According to Rot Leng, Khmer troops tried to get around the Marine position, but were stopped by "stubborn resistance."

The fourth man was described as wearing a Navy uniform and carrying medical supplies. If true, he had to be either Bernard Gause or Ronald Manning, both medics, the only Navy men among the missing. And also, if the story is correct, he had to not only survive the helicopter crash of Knife-31, but also make it safely ashore and through the heavy jungle to reach the three Marines.

With the possibility that some servicemen survived the battle, identifying the recovered bones has become even more important. So far, Army scientists have identified seven separate DNA sequences among the 161 bones. Those sequences are being compared with DNA samples from relatives of the missing men.

POPULAR SCIENCE has learned that at least one match has already been found: One of the DNA sequences matches a sample provided by a relative of Lt. Vandegeer. The sequence was found in a section of jawbone, and tooth

Identifying the Unknown Soldier

BURIED IN THE TOMB OF THE UNKNOWNS at Arlington National Cemetery are the remains of unidentified soldiers from World War I, World War II, and the Korean conflict. But the Vietnam War soldier who was once buried alongside them may not be unknown forever.

In May, with the approval of Defense Secretary William Cohen, the Vietnam-era bones were exhumed for identification by mitochondrial DNA analysis. The technique was not available when the soldier's remains were entombed 14 years ago.

The relatives of 1st Lt. Michael J. Blassie, an Air Force pilot shot down in 1972, believe the bones are his. Blassie's identification card was found near the remains. However, forensic examiners say the bones are those of a man who was shorter, older, and had a different blood type than Blassie. They may belong to Capt. Rodney L. Strobridge, an Army helicopter pilot shot down in the same area on the same day.

L.E. BOGARD JR./DEPT. OF DEFENSE

Mitochondrial DNA analysis didn't exist when the remains of the unknown serviceman of the Vietnam era were interred.

In an effort to resolve the matter, the Pentagon plans to test DNA samples from family members of all nine service members who are believed to have died in the two aircraft crashes.—*Dawn Stover*

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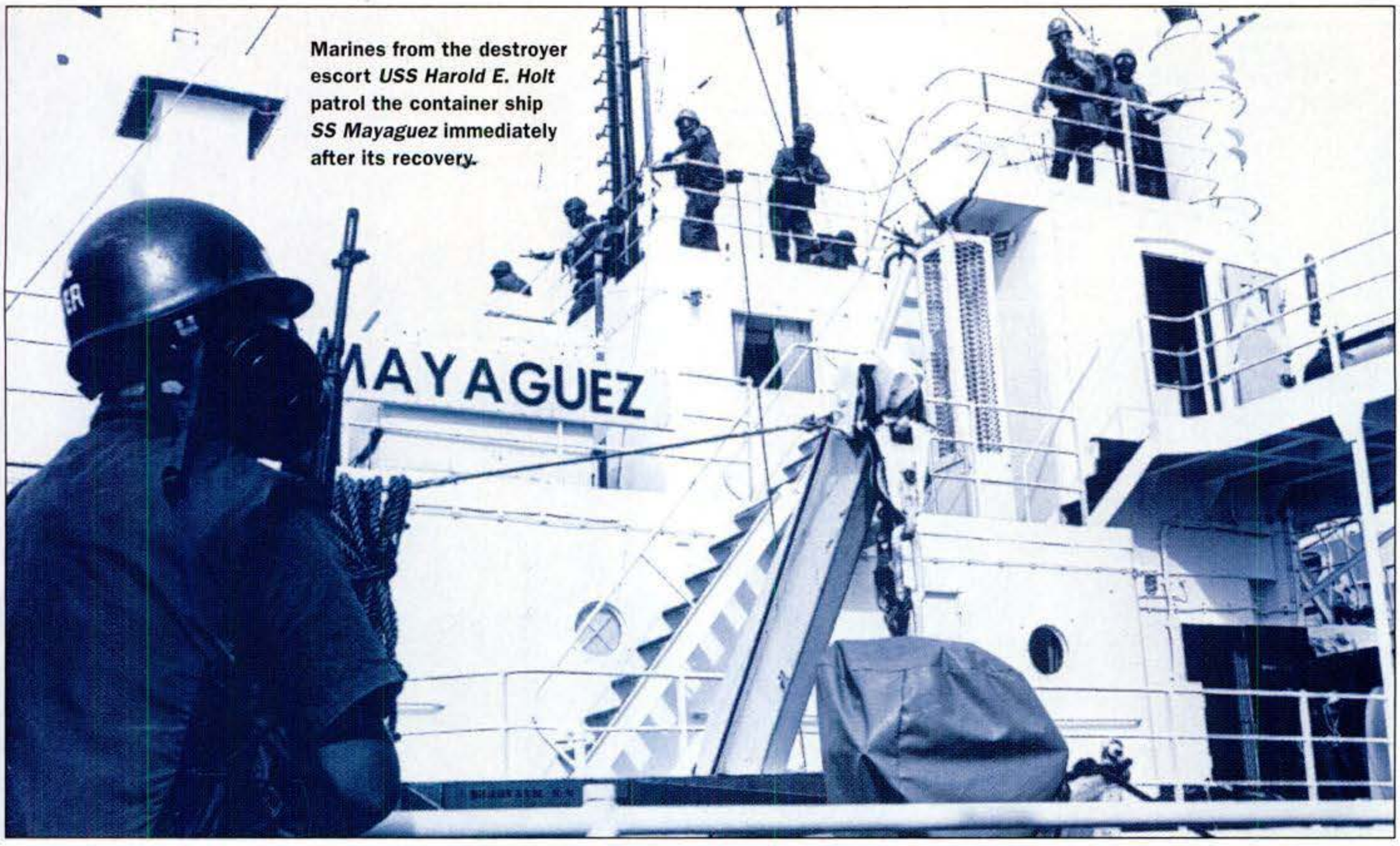

Marines from the destroyer escort *USS Harold E. Holt* patrol the container ship *SS Mayaguez* immediately after its recovery.

NAVAL HISTORICAL FOUNDATION PHOTO SERVICE

restorations on the jawbone match X rays from Vandegeer's dental file, providing additional confirmation.

Military officials have not yet announced the match, however. "No identification has been made in the [Koh Tang] case," says an Army Personnel Command spokesperson, who will neither confirm nor deny any specific lab findings. That's because the "case" includes the entire set of 161 bones recovered from the island. Until maternal relatives of each of the missing soldiers have been tested (to eliminate the remote possibility that any of the seven DNA sequences might match more than one family line), and all of the bones have been sorted by soldier, the case remains unresolved. It will stay that way until the Central Identification Laboratory in Hawaii has made its identification recommendations, the soldiers' families have reviewed the findings, and a military review board has approved the identifications.

Using this lengthy but thorough process, the Pentagon has so far identified the remains of almost 500 soldiers who died in Southeast Asia during the Vietnam War and were initially listed as missing in action. The remains of another 250 to 300 soldiers are currently under study. Some bones are so fragmented or charred, however, that they may never be identified—at least not until technology takes another leap forward.

But already it is feasible to identify virtually every American soldier who falls in battle, as long as the body can be recovered quickly. This is possible because the Pentagon now stores a blood sample from each active-duty soldier at a DNA repository in Maryland. By comparing the nuclear DNA in a blood or tissue sample from the fallen soldier with the DNA on file, scientists can make an exact identification.

But for ancient remains like those found on Koh Tang, mitochondrial DNA analysis is the tool of choice. With the help of this new technique, the bones of seven soldiers who died inside Knife-31 may soon go home.

As many as four men may have been left behind—and very much alive—on Koh Tang.

For the 11 other soldiers who never returned, however, the story isn't over. What became of Hargrove, Hall, Marshall, Gause, and Manning? Were they killed in action on the island, as the Pentagon concluded? Or were four men taken to the Cambodian mainland and imprisoned there, as Rot Leng claims? Will their remains eventually be found in Cambodia's notorious killing fields? The Joint Task Force investigation into their fate continues.

Mitochondrial DNA technology may someday tell us if the story of three heroic machine gunners, and a Navy medic who made his way through the jungle to join them, is myth or reality. Maybe Lt. Richard Vandegeer was not the final casualty of the Vietnam War after all. ◆

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Inventions here, there, everywhere: Surrounded by self-designed furniture, including the lamp, and awash in blueprints, Rabinow explains the self-governing watch it took industry a decade to warm up to.

Gadget Master

Jacob Rabinow was the government's gadget guru for 50 years. At 88, he's still tinkering away.

By Gunjan Sinha

JACOB RABINOW SLIDES a crooked finger across the top of a glass display case that holds the first magnetic computer disk, a magnetic particle clutch for engines, the first automated letter sorter, and a self-regulating watch—just four of his more than 200 inventions. Pointing to each one in succession, he recounts its conception as if he'd conjured it up only yesterday: "I developed that magnetic disk in 1948 and people said, 'Who needs it?' I told them it's simply a better way to do it." That need, to cook up better ways to do things, has motivated eight decades of invention.

"I always dreamed of being an inventor," he says. Born in the former Soviet Union, Rabinow concocted his first gadget—a rock thrower—when he was 8. By the age of 11, he was living in the United States. Now at 88, he has won this year's prestigious MIT-Lemelson award for a lifetime of achievement in invention. The award is meant to serve a dual role—recognizing Rabinow while inspiring American inventors in general. The number of patents issued to Americans in many areas of former expertise is steadily declining as inventiveness moves offshore.

"We were all so impressed by the scope of his creativity," says Cynthia Robbins-Roth, editor-in-chief of *Bioventure View*—a monthly newsletter concerning the biotechnology industry—who served as a judge on the MIT award committee. "Rabinow's inventions had an impact on an extremely diverse group of industries," she says.

For 50 of the past 60 years, Rabinow has worked in some capacity for the National Institute of Standards and Technology (NIST) in Gaithersburg, Maryland, whose mission ranges from setting measurement standards to financing the development of new technologies. Rabinow began his career there calibrating instruments but quickly climbed the ranks after building a reputation as an innovator, eventually becoming chief research engineer. Rabinow headed various projects for the agency and most of his gadgets took root there. He scaled back his hours 20 years ago and today divides his time between fiddling with new gadgets in his modest workshop at home; playing tennis with Gladys, his wife of more than 55 years; and reviewing funding applications part-time for NIST. He presently has one patent pending on a pick-proof lock and two more in the works.

In his custom-built home, Rabinow's ingenuity is evident in little details—even in how he hangs his pictures. Rabinow is an avid photographer and

PHOTOGRAPHED BY JOHN B. CARNETT

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photos of family and friends line the halls like wallpaper. Not wanting to mar the walls, he taped the framed photos to pieces of fishing-wire and then slung them from a piece of wooden molding he had hammered on the wall. That way he could easily change the photos' positions and also flip them over to read where and when they were taken.

Rabinow has had his share of what he terms "unimportant inventions"—not because they were not good ideas, but because no one was willing to commercialize them. "Inventors probably come up with hundreds of ideas that you never see, because no one would want to make them," says Rabinow. **In fact, convincing someone to manufacture an invention is the biggest obstacle for an inventor,** he adds. "They're [inventions] always too expensive, too cheap, too different, too much the same—always too something," he says.

Even selling his self-regulating watch—a gadget that appeared to be an obvious improvement on existing watches—was a battle. Before the widespread use of quartz, watches contained an internal lever through which their rate could be increased or slowed down—an adjustment that was very often needed. But that required prying the back and risking damage to the watch. So in 1945, Rabinow patented a watch in which the rate regulator was coupled to the arms on the timepiece. Moving the hands changed the rate slightly, and once it was done a few times, the watch would run correctly.

Rabinow pitched the idea to watch companies, but none would buy it. Finally, Rabinow struck a deal with the president of another watch company, General Time, completely by chance. They were returning from a meeting in the same car when, during a conversation, the president inquired about the watch. He offered Rabinow $10,000 a year plus a penny a clock for the rights to the technology. General Time made the clocks for about 20 years and Rabinow earned between $20,000 and $30,000 a year in royalties.

Surprisingly, that was the most money Rabinow ever earned from any of his inventions. Many of them were developed at NIST, and any technology built with government money belongs to the government—meaning anyone in the United States can use it for free. The display case in his home, which also includes a headlight dimmer and proximity fuses for guided missiles, is a reminder of this fact. Rabinow is credited, but paid only if a company asks him to develop an invention further.

But Rabinow has no regrets. "I lived comfortably and did what I loved to do," he says adamantly. In fact, he advises inventors to get jobs in research and development divisions rather than shop their inventions around. "Sometimes marketing is a matter of luck, and it's easier to get people's attention if you're already on the inside," he says. And for the individual inventor, marketing a new invention is only going to get tougher. "Companies are buying each other up, and the bigger they get, the more conservative they get—that's inherent in size," he adds. Companies are reluctant to invest in something radically new because they're so heavily invested in the old, he explains: "It's like fighting the inertia of the human race." But if you want to make money and are willing to take a risk, Rabinow suggests opening your own company to manufacture and market a device and then selling the company when it becomes profitable.

The mega-merger trend is just one factor contributing to the troubling decline in American inventiveness, says Rabinow. Another factor, he says, is the mass migration of America's manufacturing jobs to other countries. "People think you can do the engineering here and manufacture the product in places like China," he says. "In the long run, the people who produce the stuff will learn how the thing works, and do the engineering themselves." As evidence, Rabinow points to the declining number of patents issued to Americans in technologies such as cameras and automobile engines. More than 70 percent of patents recently issued for innovations in each of these two disciplines have gone to foreigners. The only inventions of which America is still the champion, according to Rabinow, are computers and software. But "how long that will last?" he asks. ◆

Inventors Marketplace

LOOKING FOR information on inventing, including how to patent or sell your creation? A few helpful Web sites:

www.inventorsdigest.com
The United Inventors Association (UIA)—an umbrella organization for many regional U.S. inventors' groups.

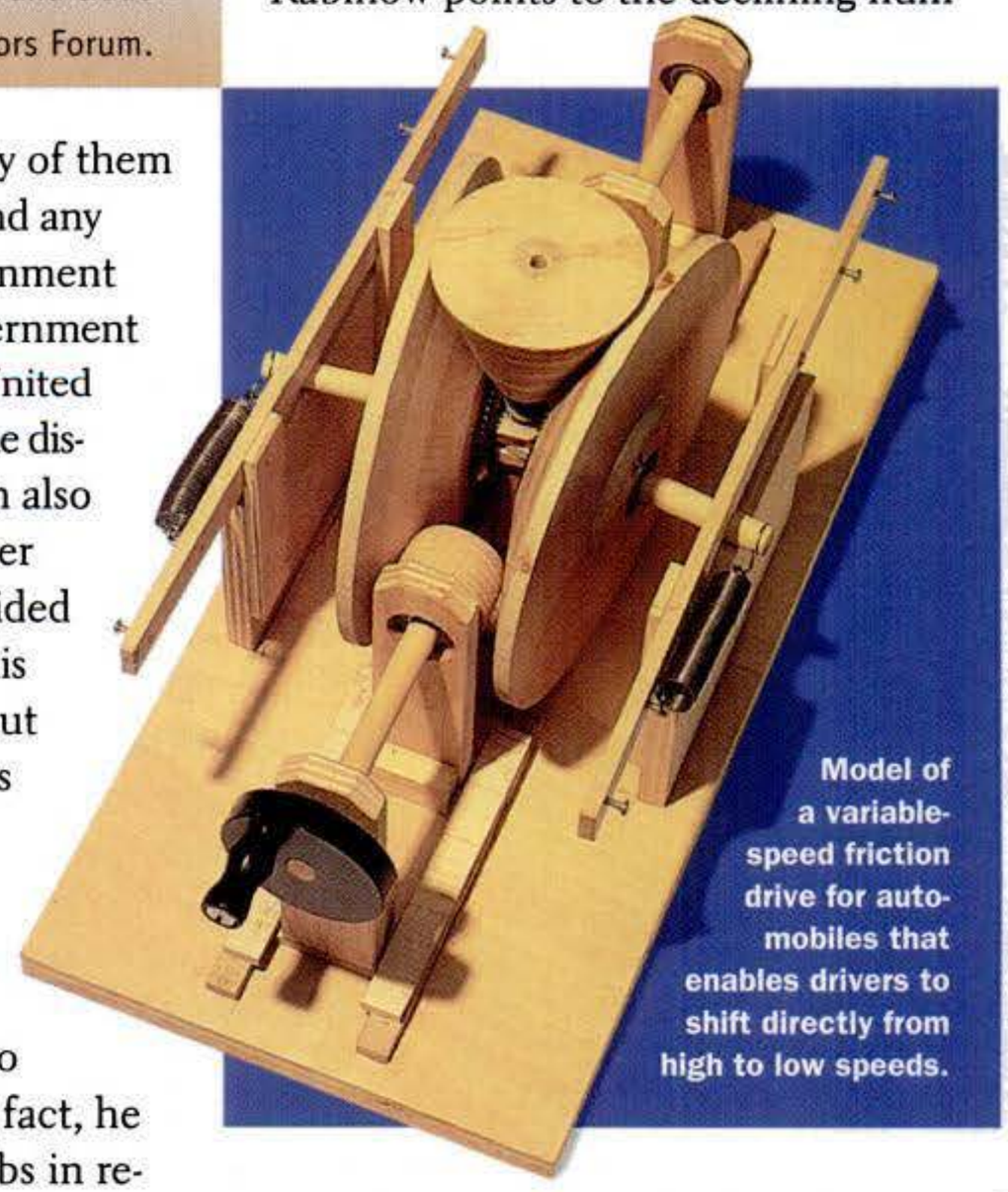
www.geocities.com/CapeCanaveral/3861
Inventors Net—publishes new ideas on its Web site for potential buyers.

members.aol.com/mikinient/index.html
Institute of Inventors—a nonprofit organization of inventors that gives advice.

www.inventions.org
Inventors Assistance League—helps inventors protect and market their inventions.

patents.uspto.gov
U.S. Patent and Trademark Office—contains an index of patents issued since 1976.

www.popsci.com/context/forums
Discuss your invention or idea and trade tips at POPULAR SCIENCE's Inventors Forum.



Model of a variable-speed friction drive for automobiles that enables drivers to shift directly from high to low speeds.

Play guess the celebrity inventor www.popsci.com

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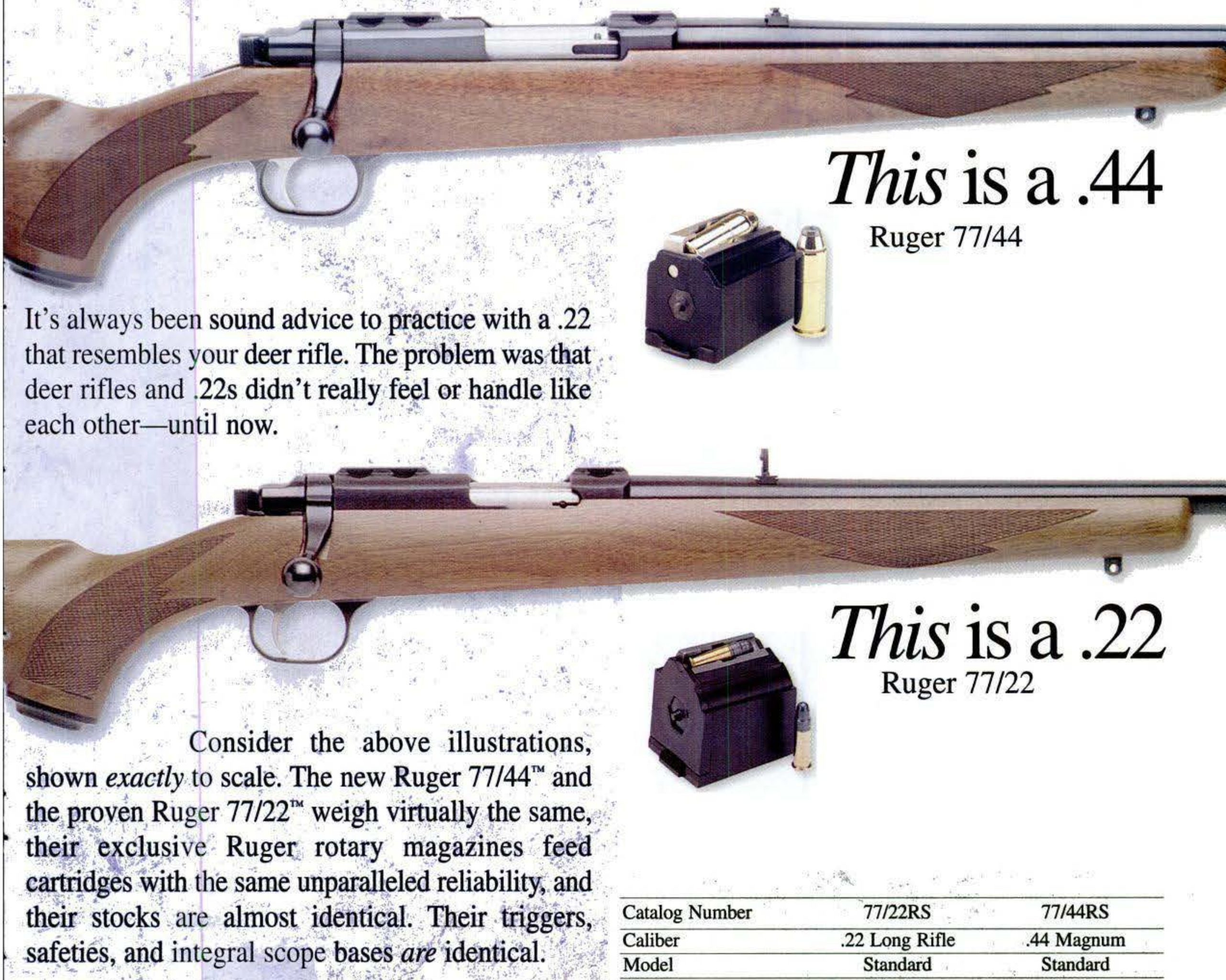
RUGER 77/44™



This is a .44

Ruger 77/44

It's always been sound advice to practice with a .22 that resembles your deer rifle. The problem was that deer rifles and .22s didn't really feel or handle like each other—until now.

This is a .22

Ruger 77/22

Consider the above illustrations, shown *exactly* to scale. The new Ruger 77/44™ and the proven Ruger 77/22™ weigh virtually the same, their exclusive Ruger rotary magazines feed cartridges with the same unparalleled reliability, and their stocks are almost identical. Their triggers, safeties, and integral scope bases *are* identical.

The compact, powerful .44 Magnum deer rifle is now as fast handling and easy to carry as your favorite .22. Make the comparison for yourself at your local dealer. And next season go out and bag that game with *Ruger certainty.*

Catalog Number	77/22RS	77/44RS
Caliber	.22 Long Rifle	.44 Magnum
Model	Standard	Standard
Stock	Walnut	Walnut
Finish	Blued	Blued
Weight	6 lb	6 lb
Barrel Length	20"	18 1/2"
Overall Length	39 1/4"	38 1/4"
Scope Rings Included	Yes	Yes
Iron Sights	Yes	Yes
Suggested Retail Price	$481.00	$575.00

Free instruction manuals for all Ruger firearms available on request.

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Arms Makers for Responsible Sportsmen

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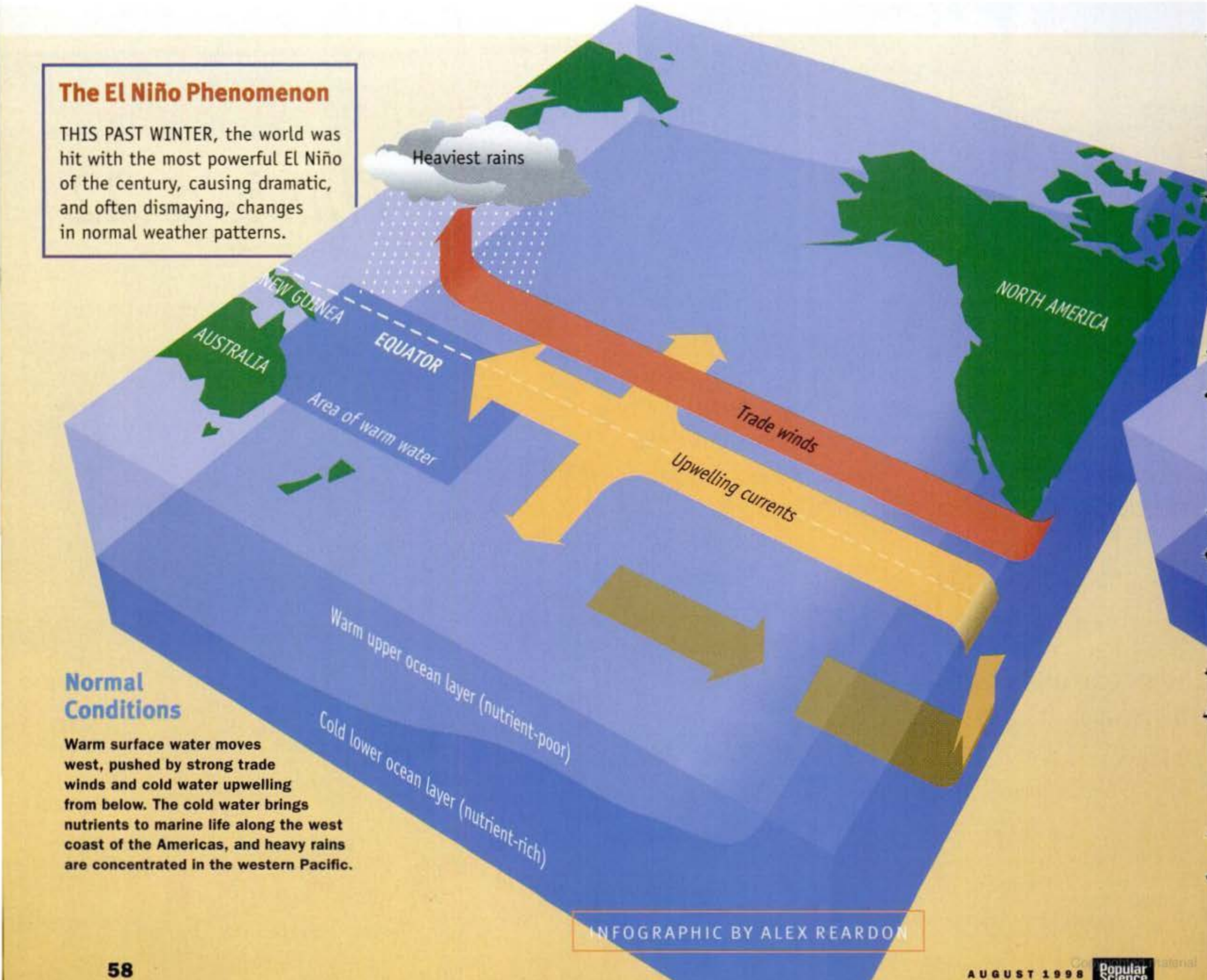
Forecast for El Niño

Powerful new tools are dissecting this year's El Niño. Now scientists can better predict what will happen next time.

The El Niño Phenomenon

THIS PAST WINTER, the world was hit with the most powerful El Niño of the century, causing dramatic, and often dismaying, changes in normal weather patterns.



Normal Conditions

Warm surface water moves west, pushed by strong trade winds and cold water upwelling from below. The cold water brings nutrients to marine life along the west coast of the Americas, and heavy rains are concentrated in the western Pacific.

INFOGRAPHIC BY ALEX REARDON

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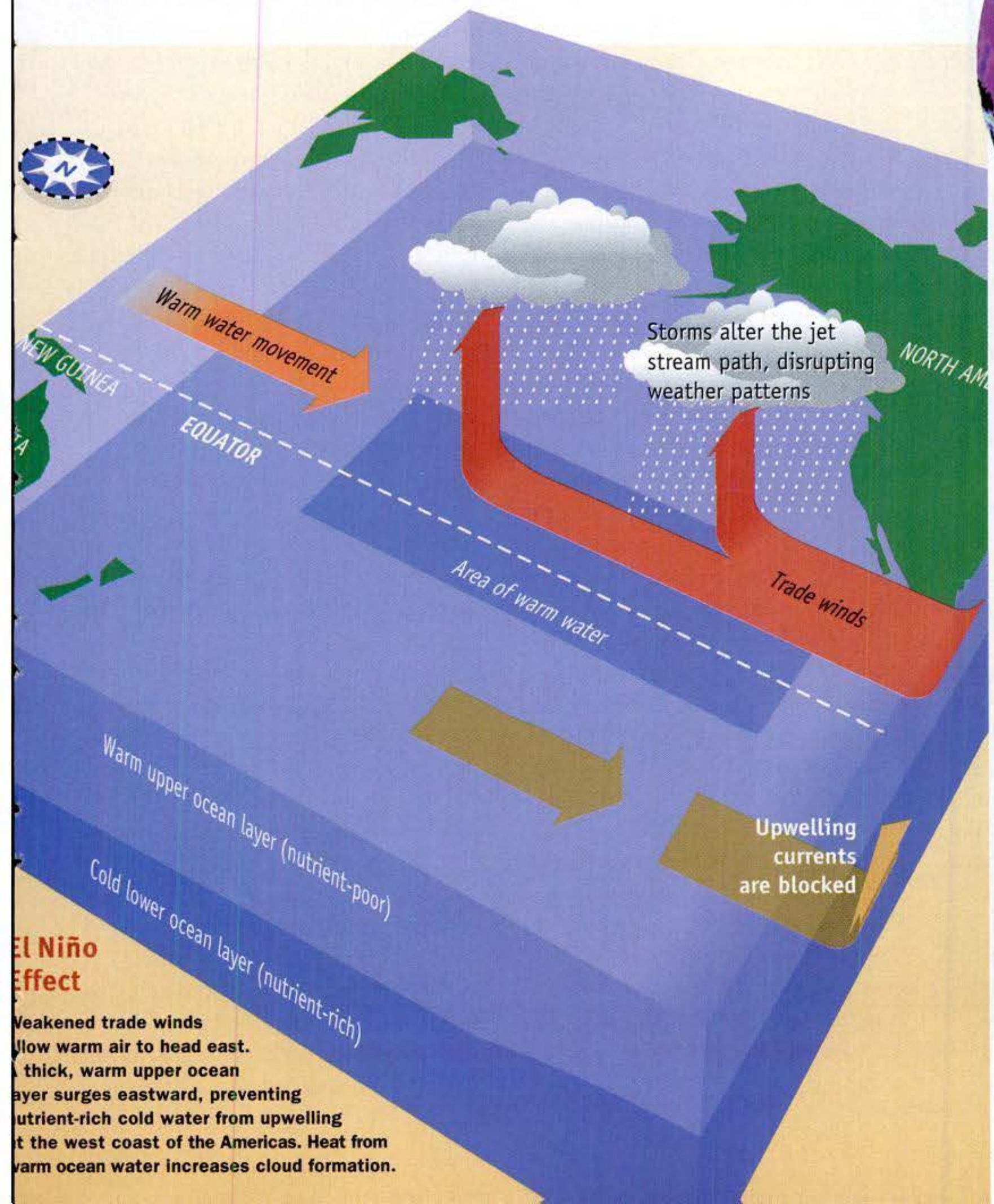
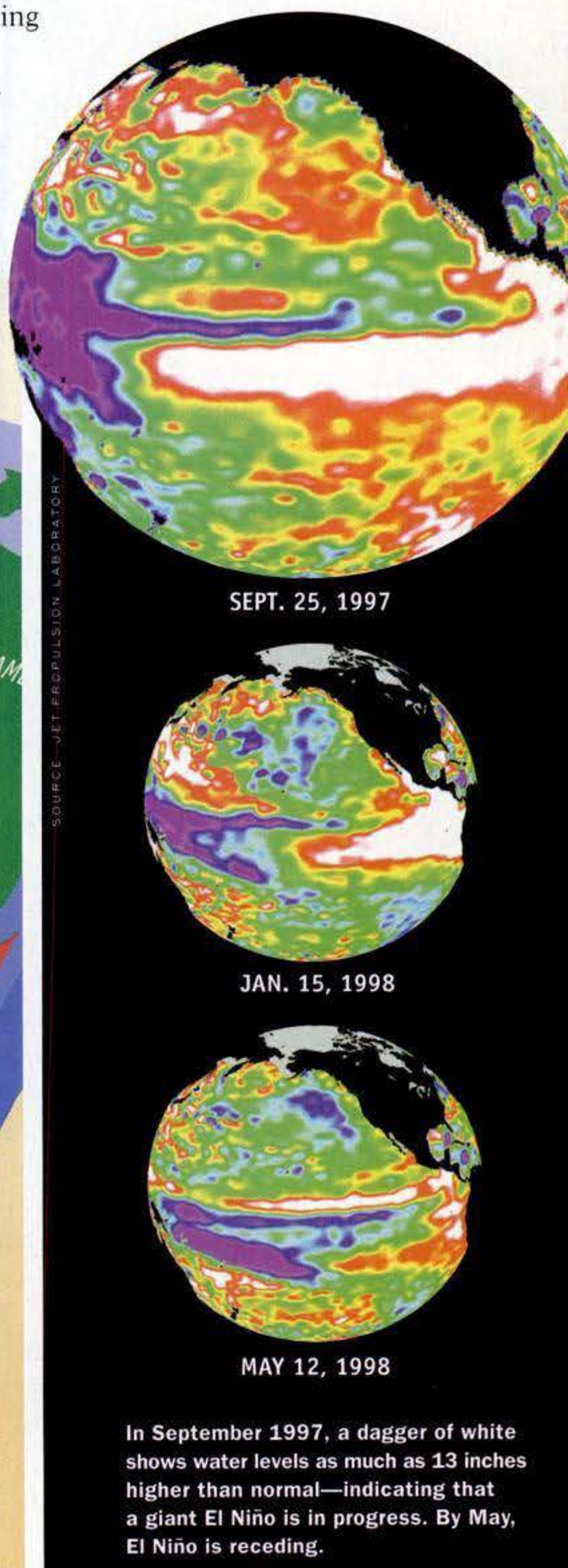
By Douglas Gantenbein

AN IMAGE TAKEN OF the Pacific Ocean last September is startling. Made using data collected from satellites monitored by NASA's Jet Propulsion Laboratory in Pasadena, California, the picture shows the surface level of the Pacific as clearly as a yardstick lying across a lumpy bed. One swatch of water—with a volume 30 times that of all the Great Lakes—is white, indicating that it is as much as 13 inches higher than its normal level. That swatch runs die-straight across the Pacific from near Australia before it torpedoes South America.

If that blob of water were put on trial for crimes against the climate, the photo might be Exhibit A. For its unusual height—caused by rogue trade winds pushing warm tropical water that belonged much farther west—was telltale evidence that the biggest, most dramatic El Niño of the century was in progress. And as the impact of that long white streak manifested itself during the following months, hardly a corner of the globe escaped. Some effects were benign: A warm U.S. winter led to record-low gasoline prices. But most were not: Flash floods killed cattle and destroyed crops in Africa. Brushfires twice the size of England scorched remote portions of drought-plagued Australia. Killer tornadoes struck the southern United States, while waves and high tides eroded West Coast shorelines. All told, a global death toll of 7,000 or more, combined with more than $10 billion in damages. "There were block-buster impacts all over the world," says Michael McPhaden, a scientist who tracks El Niño for the National Oceanic and Atmospheric Administration. "This El Niño is going to be a benchmark for years to come."

Certainly, this was the best-documented, most-watched such event in history, and will stand out as the El Niño that showed how far science has come in little more than a decade in its ability to track and analyze these events. But it also revealed how much there still is to learn. Forecasting computer models that many researchers confidently believed could predict El Niño's onset and scope failed





In September 1997, a dagger of white shows water levels as much as 13 inches higher than normal—indicating that a giant El Niño is in progress. By May, El Niño is receding.

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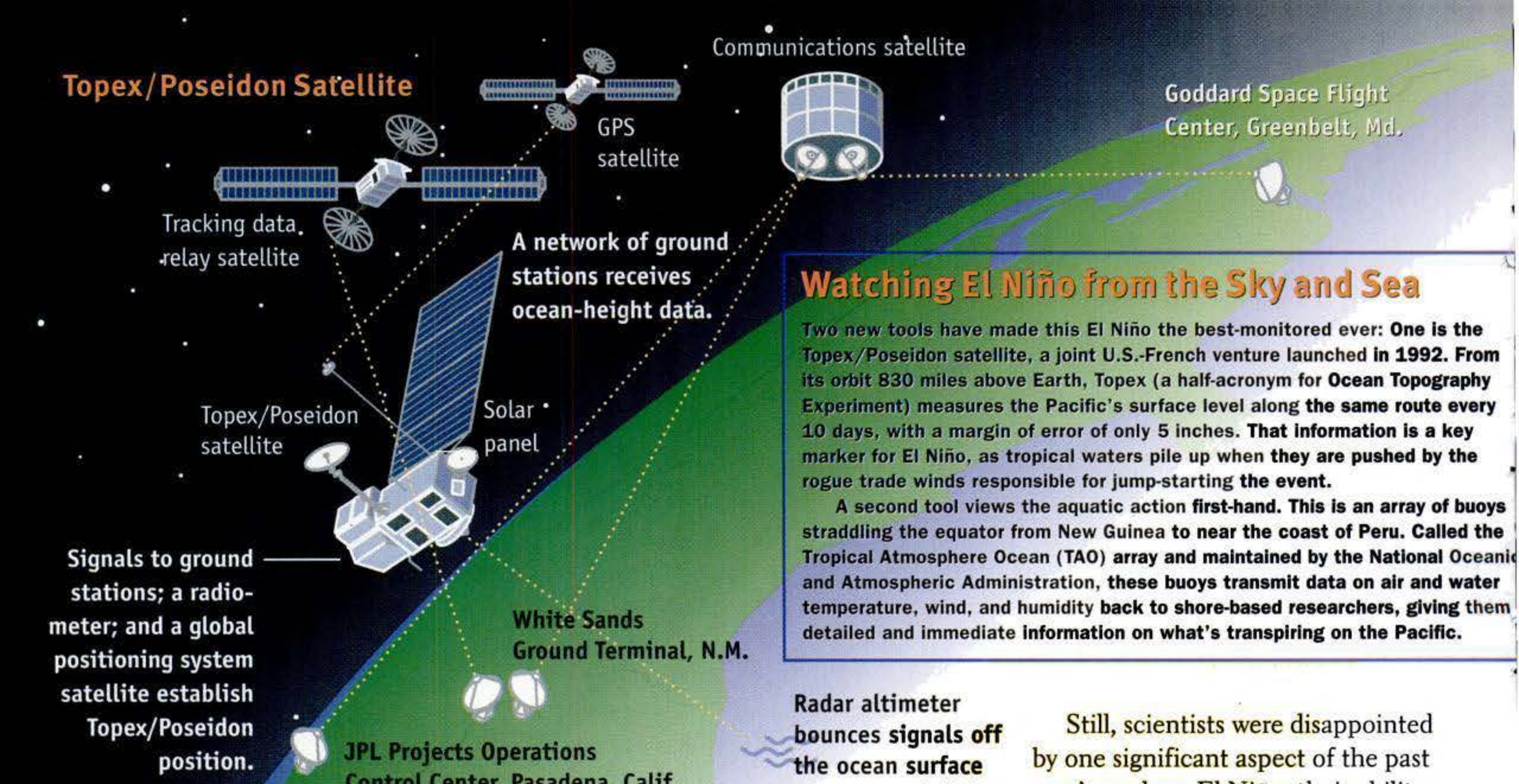
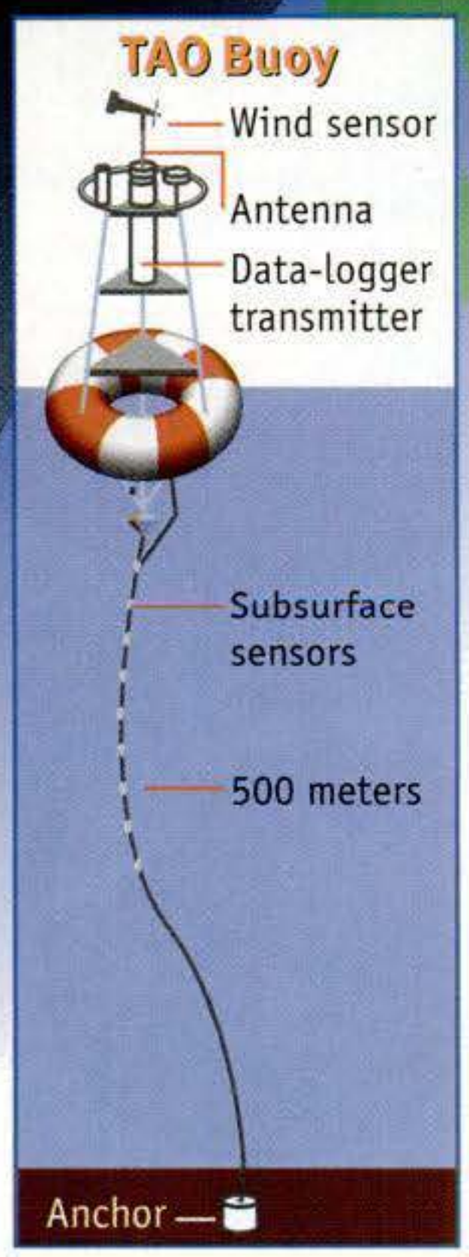


Watching El Niño from the Sky and Sea

Two new tools have made this El Niño the best-monitored ever: One is the Topex/Poseidon satellite, a joint U.S.-French venture launched in 1992. From its orbit 830 miles above Earth, Topex (a half-acronym for Ocean Topography Experiment) measures the Pacific's surface level along the same route every 10 days, with a margin of error of only 5 inches. That information is a key marker for El Niño, as tropical waters pile up when they are pushed by the rogue trade winds responsible for jump-starting the event.

A second tool views the aquatic action first-hand. This is an array of buoys straddling the equator from New Guinea to near the coast of Peru. Called the Tropical Atmosphere Ocean (TAO) array and maintained by the National Oceanic and Atmospheric Administration, these buoys transmit data on air and water temperature, wind, and humidity back to shore-based researchers, giving them detailed and immediate information on what's transpiring on the Pacific.



to hint at the scale of the emerging event, or missed it altogether. The peculiar behavior of the most recent El Niño—which arose much earlier in the year than is typical and had much different impacts—has raised questions about just how the phenomenon works. And there is a debate over exactly what has caused two decades of unusual El Niño activity.

El Niño has for centuries been a regular, if somewhat reckless, climatic event. It typically makes its presence felt around midwinter, hence a name that loosely translates as "Christ child" in the Spanish of the Peruvian fishermen who first noticed it. El Niño begins, however, some months prior to that, when trade winds in the western tropical Pacific drop or even shift, switching from blowing westward to the east. When this happens, a body of warm water that normally pools in the ocean east of Australia begins to move toward the coast of Peru. Warm air rising from the surface of this mass—which is as much as 12°F warmer than normal—acts like a paddle stuck into the southern jet stream, redirecting it northward and altering weather from Australia to Canada to Africa. The warm water itself, meanwhile, is like a cap on a bottle when it hits the coast of Peru, halting the rise of cold, nutrient-rich water that typically emerges along the South American coast from deep in the Pacific. That drastically affects the food chain for marine mammals, birds, and fish.

Scientists have grown steadily more familiar with El Niño in the past 20 years. "There's been a fundamental change since the 1982-'83 El Niño," the devastating event the 1997-'98 El Niño surpassed in size, says McPhaden. "We didn't even know that one was happening until it was almost over. In the 1997-'98 El Niño, we could tell you day by day what was happening." The reason? Two new powerful tools—**instrumented satellites and buoys—now make it as easy for scientists to watch the ocean** as if it were a wading pool in their backyard.

Still, scientists were disappointed by one significant aspect of the past year's work on El Niño: their ability to forecast it accurately. While a few computer models suggested that an El Niño would develop in 1997, none came close to predicting its scope or the speed with which it developed. Even the gold standard of forecasting turned to lead. A model developed by Mark Cane and Steven Zebiak at Columbia University's Lamont-Doherty Earth Observatory in Palisades, New York, was considered the best among El Niño forecasting models. But it didn't read the global tea leaves correctly, forecasting an El Niño that was much later and smaller than the one that actually hit.

Fine-tuning has revealed the problem. Forecasts for the 1997-'98 El Niño had been made using wind measurements gathered from ships crossing the tropical Pacific. That data had yielded good results in the past, but obviously wasn't telling the whole story. Since then, Zebiak and his collaborators have rerun the model using tidal measurements instead of wind and gotten results much closer to the actual, early-1997 El Niño. Tides run higher when there is a thicker layer of warm water beneath the surface, and so are a good barometer of undersea warming.

El Niño experts are still striving to tackle the really big question: What is causing the unusual El Niño behavior of the past two decades? As McPhaden

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notes, the El Niño of 1982 was termed the El Niño of the Century, based on its recorded impacts and anecdotal data on events that occurred earlier in the century. But the 1997-'98 event is even larger than the one seen 15 years ago, making it the El Niño of the Century as well. Moreover, early in the 1990s an El Niño effect seemed to last for three years, something never recorded or even expected, suggesting a force working behind the scenes.

But what? Some see the hand of global warming, accelerating the pace of El Niño formation and strengthening each event. Supporters of global-warming-as-El-Niño-instigator include Kevin Trenberth, a climate analyst with the National Center for Atmospheric Research in Boulder, Colorado. "There's evidence that global warming didn't have much impact until 1979, but now it's beginning to break through," he says. If global warming is influencing El Niño, says Trenberth, then we're in for some rough weather, with perhaps years on end of repeated and severe El Niño events.

Two additional arguments are on the table. One theory is that the recent El Niño epidemic is simply one of nature's climatic riffs, but that we haven't been hearing the tune long enough to recognize the change in key. One problem is that historical data on El Niño is sketchy prior to the early 1970s and almost nonexistent going back more than 50 years. If one looks back further, however, fossil evidence suggests that something about El Niño has indeed changed. Fossil records of coral in the Galapagos Islands show that some 4,000 years ago, an El Niño occurred only every 60 years or so. Studies of tree rings and ice cores indicate a more recent cycle of seven years, still much less frequent than the present cycle of every three or four years.

The other alternative? Records are accurate enough to show that we're in the second El Niño-intensive era of the past 100 years. The first was during the 1920s and '30s, and probably was responsible for the Dust Bowl, when drought destroyed hundreds of farms in Oklahoma and north Texas. The second seems to have started around 1976. These shifts seem to be due to periods of natural warming in the Pacific. The warming does not necessarily cause El Niño but certainly amplifies it, creating the appearance of more—and more severe—El Niños. "It could be that we really aren't looking at [human-caused, global-warming] reasons for El Niño," says McPhaden. "It could be just part of the zoo of climatic animals."

To learn more about other animals in that climatic zoo, scientists will deploy powerful new tools to help record or predict future events. This year, NASA's Goddard Space Flight Center in Greenbelt, Maryland, plans to have operating an upgraded Cray supercomputer. The Cray will crunch El Niño-related satellite and buoy data with the goal of refining prediction models by allowing the use of more and more-detailed data. A newer, even more powerful machine is set for installation in the year 2000. In May of that year, NASA and the French space agency CNES (Centre National d'Etudes Spatiales), plan to launch Jason-1, a follow-up to the ocean-measuring satellites currently used. Jason-1 will have twice the measuring accuracy of the current satellite network.

For the near future, the behavior of wind and water in the tropical Pacific seem to indicate that the next year or two at least will be El Niño-free. In fact, the trend may tip over into El Niño's sister effect, La Niña, a cooling event that typically has milder consequences than its warm sibling. By late spring, satellite data revealed not a torpedo of warm air slicing across the Pacific, but a tiny sliver of dissipating warmth.

Scientists, meanwhile, are already hard at work on data collected during the most recent event, something Trenberth calls "this wonderful experiment that Mother Nature puts on for us." For Trenberth and scores of researchers, El Niño offers a rare opportunity to pursue their craft and gain understanding of an phenomenon that affects millions of people: "What we're working on is not only a thrilling scientific adventure," McPhaden says. "It also has great value for humanity." ◆

From the Eye of El Niño

THE LATE WINTER sky was such a stunning shade of blue and the sun so preternaturally warm that it was hard to believe that I was about to fly into a winter storm off the California coast. With crew members and scientists, I boarded a P-3 turboprop outfitted for weather research. The flight was part of airborne experiments funded by the National Oceanic and Atmospheric Administration to provide an intimate look at Pacific storm systems during an El Niño winter.

We flew northwest from Monterey to intercept the storm center 1,000 miles offshore. The crew deployed dropsondes, torpedo-like devices that measure air pressure, temperature, and wind speeds as they drop to the ocean. Onboard computers bundled the dropsonde data and relayed it via satellite to the National Weather Service headquarters. The dropsondes provide a more detailed portrait of a storm than weather satellites.

Next, we searched for a strong current of air that travels close to the surface along the storm front. Called the low-level jet, this river of air carries moisture and heat from the ocean surface to feed the developing storm. When these moist winds carom up coastal mountain ranges, they can dump torrential rain, causing mudslides and floods. Although El Niño was universally fingered in last winter's weather woes, scientists aren't sure exactly how it influenced individual storms. "We saw several strong storms in February with unusually wide and strong low-level jets," lead scientist Ola Persson says. "I suspect there is some relationship [to El Niño], and we're going to be looking for it as we analyze the data."—*Mary K. Miller*

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E-Phones Connect

With new phones, you can check your e-mail and browse the Web without booting up.

By Suzanne Kantra Kirschner

DO YOU SEND AND RECEIVE MORE phone calls or e-mail? When you're looking for information, do you reach for the *World Book Encyclopedia* or the World Wide Web? If your answers are e-mail and the Web, or you wish they were, then a new breed of telecommunications device variously called an e-mail phone or Internet phone may soon find its way into your kitchen or living room.

What's an e-mail phone, or e-phone for short? Essentially, it's the merger of telephone and computer—or at least a tantalizing slice of what a computer provides. With most of these new screen phones, that means being able to

PHOTOGRAPHED BY JOHN B. CARNETT

PHILIPS IS-2630

PRICE: **$650**
E-MAIL: **Any service provider**
WEB ACCESS: **Yes**
SPECIAL FEATURE: **VGA color touchscreen**

read and reply to electronic mail directly from the phone, without booting up (or even owning) a PC. With some, it also means being able to scour the Web to make vacation plans or research homework assignments, albeit at slow speeds and on a rather small screen. And, oh yes, you can still make phone calls, too.

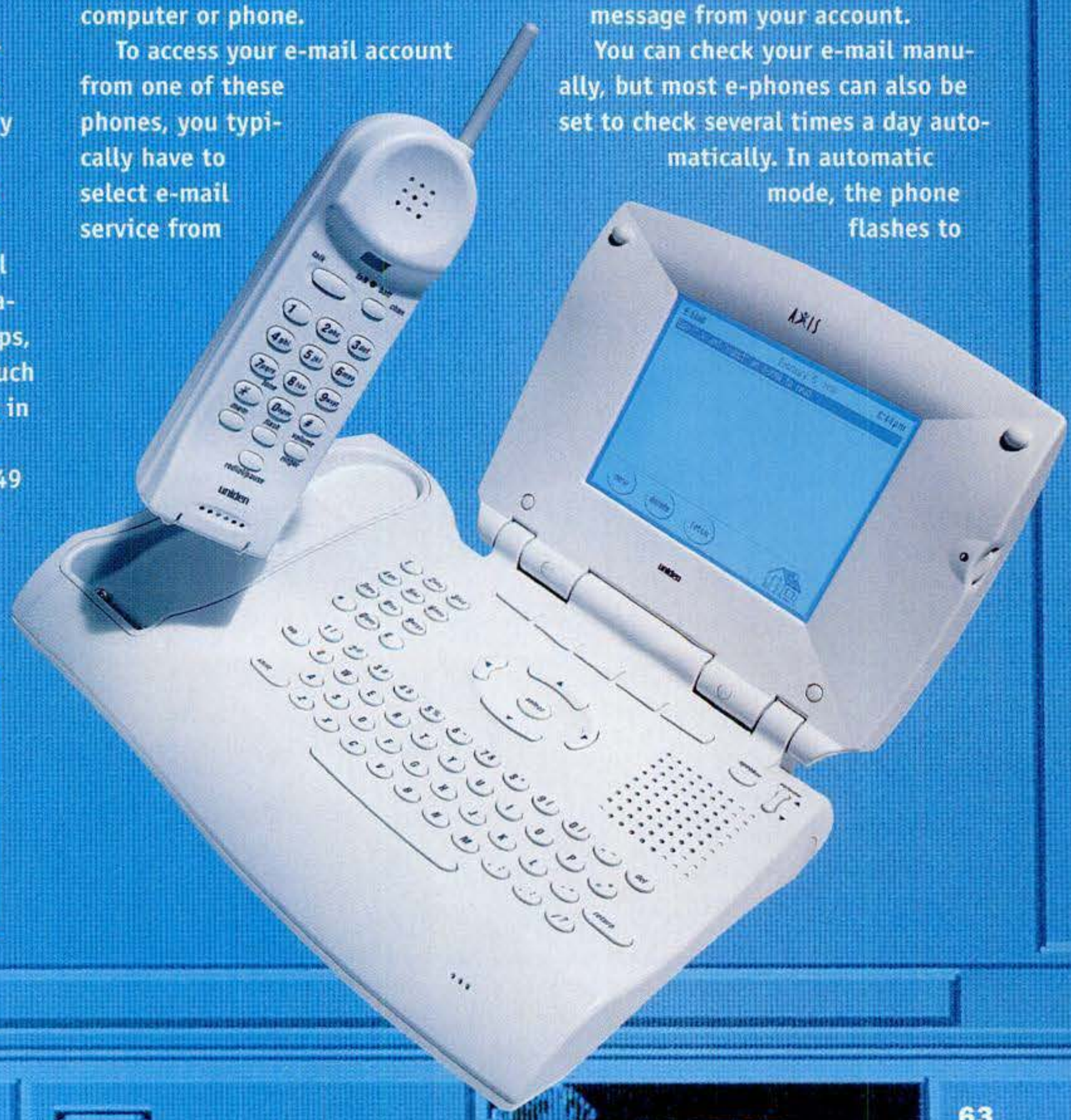
Why an e-phone? This is one invention that seems to be following our lead. Millions of us already exchange e-mail routinely with family and friends at home, not just business colleagues and customers at the office. And the kitchen or the family room is often more conducive to these personal missives than wherever the computer sits, assuming there is one. But if Internet phones serve as e-mail extension cords for the computer savvy, they also promise to get many non-wired relatives back into family circles that went electronic during the 1990s.

Though e-phones are new, you'll have more than a few choices. Alcatel, Cidco, Northern Telecom, Philips, and Uniden are each now selling such phones, or shortly will be, ranging in price from $300 to $650. Casio makes a less costly model, the $149 PhoneMate IT-380, but unlike the others, it receives only the sender's name and message subject line, not the actual message itself—for that you need a PC.

No computer experience is required to use an e-phone. Most let you sign up with your choice of Internet service provider (ISP), which typically charges about $20 per month. Some phones offer a preselected menu of ISPs, which can make getting started even easier. Ironically, it's harder to set up an Internet phone if you already have an e-mail account. You'll need to get a battery of arcane information from your current ISP, such as server authentication, domain name server (DNS) lookup addresses, and host names. Once you're past this tedious hurdle and enter this account information into the phone, you can check your e-mail from either your computer or phone.

To access your e-mail account from one of these phones, you typically have to select e-mail service from a menu. Phones with touchscreens have an icon for that on the opening screen. For other phones, you press one of the buttons lining the bottom or sides of the display, much as with an ATM machine. The phone then calls your ISP. When the ISP picks up, the phone automatically transfers your account name and password. Once accepted, the ISP will start sending the phone your messages. They appear in a list with the name of the sender, the subject of the message, and the date the message was sent. By touching the item you want to read or hitting a button next to it, the message will be displayed. Once you've read it, you can reply to the message, move on to the next one, or, with most phones, delete the message from your account.

You can check your e-mail manually, but most e-phones can also be set to check several times a day automatically. In automatic mode, the phone flashes to



UNIDEN EP 200

PRICE: **$450**
E-MAIL: **Any service provider**
WEB ACCESS: **No**
SPECIAL FEATURE: **Cordless phone handset**

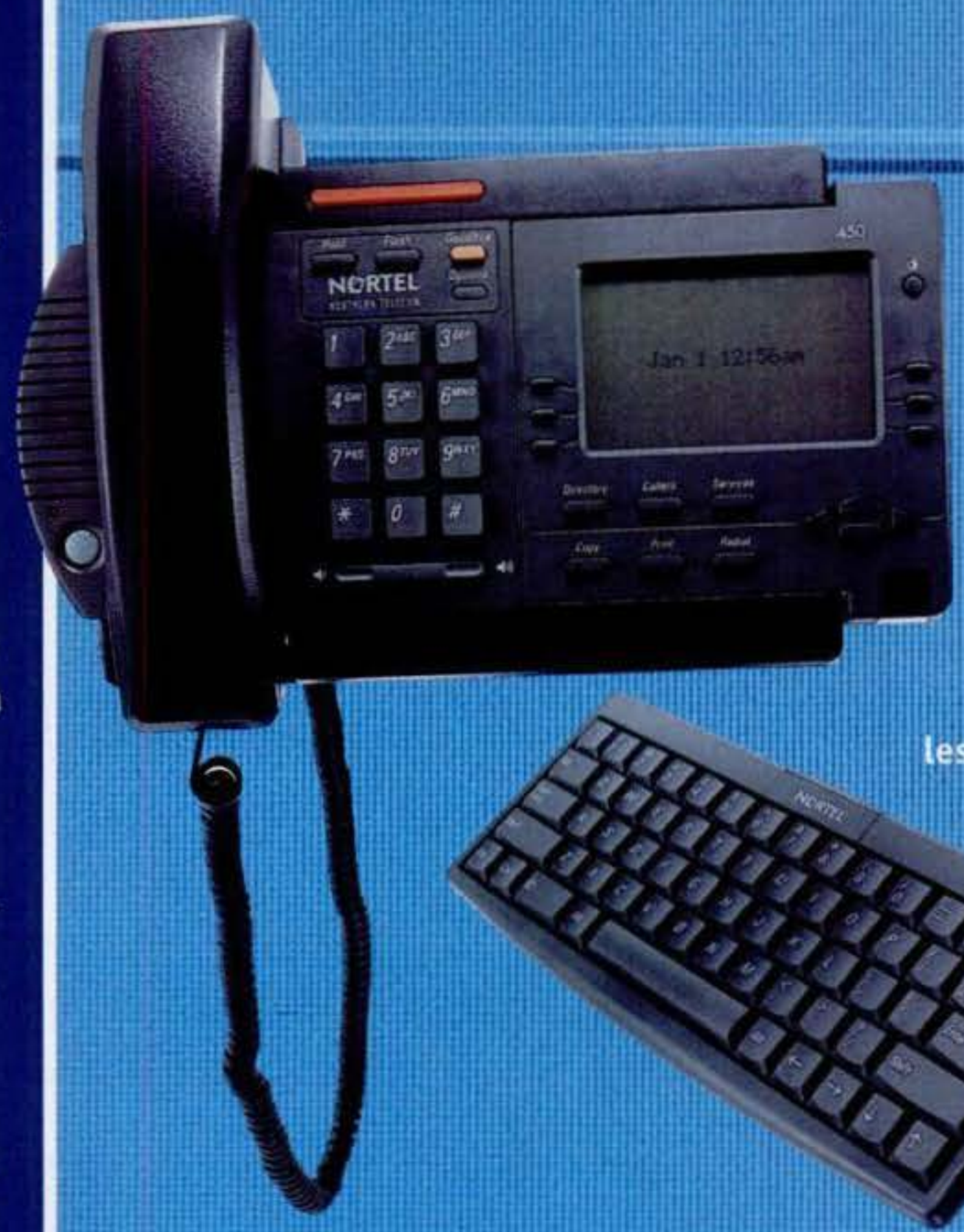
Now Brewing: Java Phones

WHILE TODAY'S Internet phones let you exchange e-mail and maybe do some Web browsing, tomorrow's promise to put an array of products and services at your fingertips, much the way France's Minitel terminals have been doing for years. And the enabling technology will be Sun Microsystem's Personal Java operating system software.

Personal Java can turn a screen phone into a device that can run computer programs, enabling you to order anything from airline tickets to a pizza, either directly or via the Internet. You might call the pizza place as usual, for example, but use a Java "applet" running on the phone's screen to check off your toppings, select a size, and hit the order button. You could even pay for the pizza with a Java smart card, a product that is already being tested.

Not all of a Java phone's added features would necessarily be about purchases. You might be able to subscribe to services that deliver wake-up calls, or remind you about impending anniversaries and birthdays. Other services, such as weather and school reports, might be more local in nature.

Alcatel's model, the 2840 (see main story), is expected to be the first Personal Java phone when it arrives this fall. There are no Java-based services for this phone to take advantage of yet, but some shopping services may be available before the end of this year. Samsung and Northern Telecom say they'll each have Java-based phones ready in early 1999.—*S.K.K.*



NORTHERN TELECOM POWERTOUCH 450

PRICE: $299
E-MAIL: SmartServe
WEB ACCESS: No
SPECIAL FEATURE: Optional wireless keyboard ($70)

tell you mail is waiting. If you happen to be using the phone when it is scheduled to check for e-mail, the phone will automatically try again when the line is free.

E-mail by any means can be habit-forming, so it's worth paying close attention to your keyboard options with these phones. The Philips IS-2630 and Northern Telecom Powertouch 450 phones have full-size, wireless keyboards that can be stashed elsewhere when not in use. The others have keyboards built into their units, or tucked away in a slide-out drawer. The wireless variety are by far the easiest to type on. The slide-out keyboards are considerably smaller and more cramped, and a keyboard drawer adds to the overall size of the phone. But you can't lose the keyboard, and you will never have to replace the keyboard's batteries, as you do with the wireless models.

One serious drawback to e-mail by phone is that none of these models can receive (or send) attached files, whether they contain documents or graphics. And since swapping pictures of the kids or grandkids via e-mail appendages has become one of the more appealing aspects of electronic messaging, that's a real loss. Some phones will attempt to display simple text files as part of the message, but other types of files will appear as gibberish, or not at all. If you share the e-mail account with a PC and don't delete the message, however, you can usually retrieve the message and file on your computer.

Screen size matters, too, especially

CASIO PHONEMATE IT-380

PRICE: $149
E-MAIL: Any service provider (sender name and subject only)
WEB ACCESS: No
SPECIAL FEATURE: Answering machine

CIDCO IPHONE

PRICE: **$500**
E-MAIL: **Any service provider**
WEB ACCESS: **Yes**
SPECIAL FEATURE: **VGA black-and-white touchscreen**

on e-phones designed to cruise the Web as well as park your e-mail. The Northern Telecom and the Uniden phones, for example, which give you access to e-mail but not the Web, have small, two-tone backlit displays, measuring about 3.5-inches square. By contrast, the Alcatel, Cidco, and Philips phones have displays about twice that size and are touchscreens. Cidco uses a high-resolution (640 by 480 pixels) black-and-white display. The Alcatel and Philips displays are the same resolution, but in color.

Starting a Web browsing session is similar to retrieving your e-mail. You touch a button or screen icon and the phone dials your ISP. Once connected, the default page (often a Web search page like Yahoo or Excite) is displayed. The quality of the graphics is surprisingly good on these phones, but the images are not as big or as sharp as on desktop PCs.

And the Web browsers built into these phones are more limited than on their PC counterparts. Often, the software doesn't recognize some formatting codes, so pictures can pop up in odd locations. Many helper programs—such as Java, RealVideo, and Shockwave—that add video, audio, or animation to Web pages are not available, either. But for retrieving basic information, checking stock quotes, and so on, the phones are adequate Web surfers.

They are not especially fast surfers, however. The modems integrated into these phones are usually 28.8- or 33.6Kbps models, and you can't trade up later to a higher-speed modem, as you can with PCs. They are up-to-date in most phone features: Most support caller ID, call waiting, and call logging. The Cidco, Philips, and Uniden models have calendars and phone directories as well. Only the Casio model has a built-in answering machine, but most support voice mail notification if you subscribe to your local phone company's voice mail service.

More phones are on the way. Early next year, Samsung and others expect to sell Java-based e-phones that will offer even more features and services (see "Now Brewing: Java Phones"). In particular, electronic banking and shopping services are expected to be a part of that expanded menu of options.

Are e-phones really ready for the kitchen? Maybe. Certainly, many of these models cost more than we're used to spending on phones, and they offer something less than the kind of full e-mail and Web browsing capabilities we're used to with computers. But the notion of a universal message center has at least been spawned into the real world, and the kitchen may never quite be the same again.

ALCATEL 2840

PRICE: **Not yet set**
E-MAIL: **Any service provider**
WEB ACCESS: **Yes**
SPECIAL FEATURE: **Smart card reader**

Tomb Rover

A small robot will enter the Chernobyl nuclear reactor to investigate leaking radioactive waste.

By Matt Richtel

PHOTO-ILLUSTRATION BY
BOB SAULS/
JOHN FRASSANITO & ASSOCIATES

Drill

Camera and light tree

Bulldozer blade

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TECHNOLOGY DEVELOPED to explore Mars may now help scientists navigate a hostile environment here on Earth: the decimated remains of the Chernobyl nuclear reactor. If all goes as planned, a robot armed with NASA technology will comb through the abandoned reactor later this year in an effort to stave off further disaster.

When the reactor exploded 12 years ago, workers hastily encased the structure in a 198-foot-tall tomb made of concrete and steel. Now rain is leaking into the sarcophagus, creating puddles of deadly nuclear waste that could seep through the reactor's floor and contaminate ground water.

Assessing the situation inside the sarcophagus is difficult, because radiation precludes extensive exploration by humans. Enter Pittsburgh-based RedZone Robotics, which makes miniature bulldozers that are used to clean up nuclear waste sites and other environmental hazards.

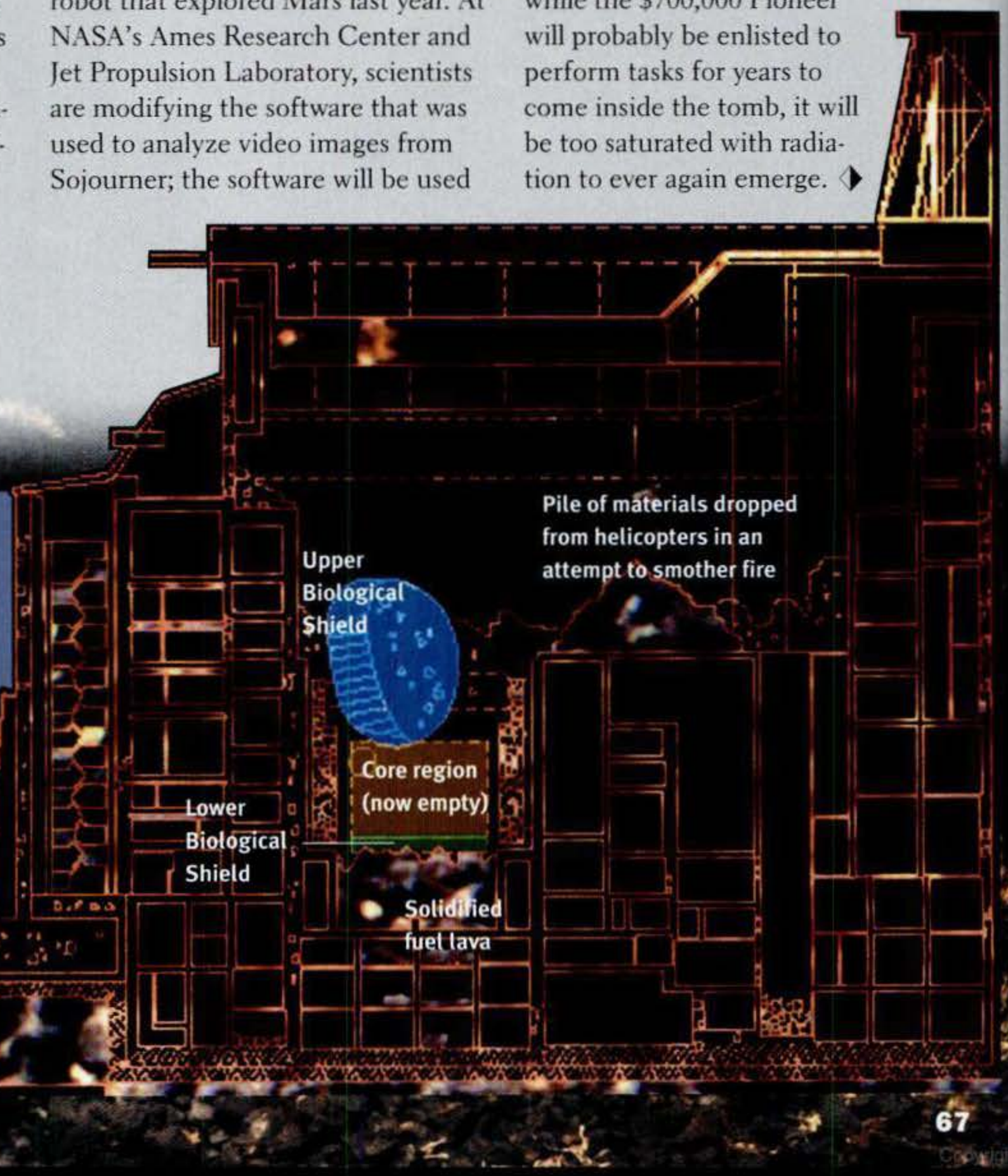
RedZone is building the Pioneer, a desk-size robotic bulldozer that moves on tractor treads. Using a cable attached to the vehicle, and three cameras mounted on it, Ukrainian operators in a lead-lined room will guide the radiation-hardened Pioneer through the sarcophagus. The robot will not only survey the scene, but may also drill out a sample of concrete to determine just how badly the tomb has deteriorated. (It is still undecided whether Pioneer will be allowed to extract any nuclear waste.) RedZone expects to deliver the robot to the Ukrainians this month.

This is not the first attempt to explore the tomb using a robot. Over the years, Ukrainian scientists have used a variety of remote devices inside the reactor. But the Pioneer robot, which will be the first Western technology used at Chernobyl since just after the initial disaster, is expected to withstand the harsh environment better than earlier robots.

Pioneer also makes use of technology developed for the Sojourner robot that explored Mars last year. At NASA's Ames Research Center and Jet Propulsion Laboratory, scientists are modifying the software that was used to analyze video images from Sojourner; the software will be used to create a three-dimensional photorealistic model of the Chernobyl reactor. When the video images from the Pioneer robot are combined with the computer model, the scientists will be able to precisely determine the size of objects inside the tomb, and the distances between them. "We can see where the molten pools of lava have gone through the floor, and figure out how to get at them," says Daryl Rasmussen, a computer scientist at Ames.

Ultimately, the virtual map will be turned over to the leaders of the G-8 nations, which have agreed to spend $300 million for a Chernobyl cleanup. It is hoped they will use the information to determine which areas of the tomb are most in need of shoring up, and how the reinforcement can be accomplished.

As for Pioneer, it likely will find the Chernobyl sarcophagus to be its own final resting place. The robot's creators at RedZone say that while the $700,000 Pioneer will probably be enlisted to perform tasks for years to come inside the tomb, it will be too saturated with radiation to ever again emerge.



What happened during the accident: Overheated fuel in the core mixed with coolant, producing a huge steam explosion. A containment structure called the Upper Biological Shield was hurled into the air, and landed in the mouth of the reactor shaft. Fuel lava melted through a 6-foot-thick shield below the reactor, solidifying as it cooled.

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The Brat

Popular Science TEST GROUP

ISUZU
Amigo

MAZDA
Miata

MERCURY
Cougar

VOLKSWAGEN
New Beetle

PHOTOGRAPHED BY JOHN B. CARNETT

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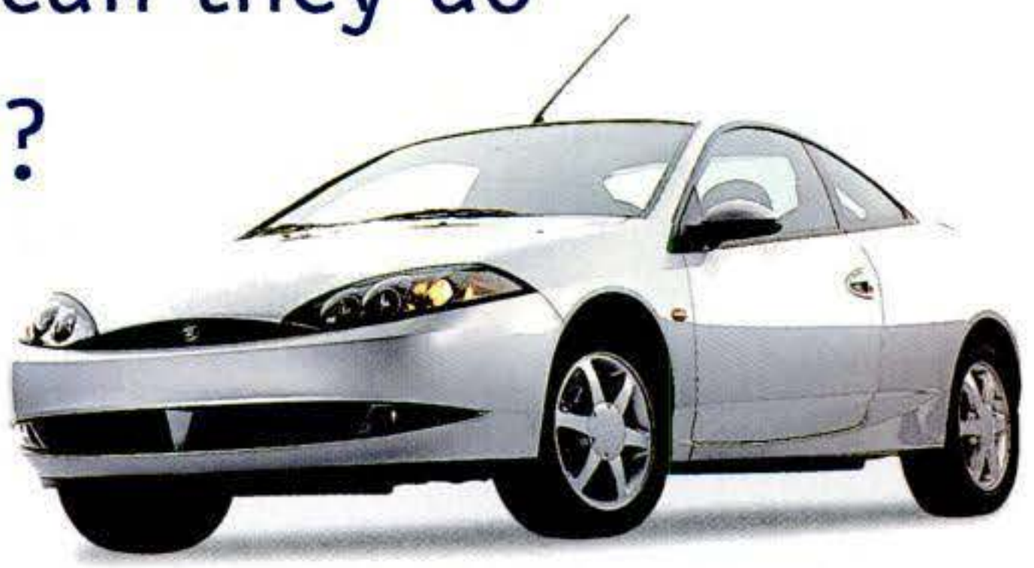
Pack

These cars epitomize hip, but can they do more than grab your attention?



By Dan McCosh

THE BEST NEW CARS AND TRUCKS, history shows, confound the formula that Madison Avenue likes to call "selling sizzle rather than steak." Cars without solid performance as well as personality rarely get further than the showroom.

That could be bad news for the most provocative cars on the road this year, four new vehicles that sing a song of self-expression: either a paean to the past, a rap to off-roading, or a road hugger's smooth, light jazz. The issue: Can they possibly deliver enough sirloin to pass muster with the masses?

Our quartet of '99 models—the new Volkswagen Beetle, Mazda Miata, Isuzu Amigo, and Mercury Cougar—may appear mismatched. After all, a stylish urban people-mover; a wind-in-the-face sports car; a

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rugged sport-utility; and a sleek sport coupe don't have a great deal in common. But if you're looking to make a statement about who you are, each of these autos articulates—with fun and flair. If you prefer to blend in, don't drive one of these cars.

The New Beetle is the reborn leader of a personality cult, an improvisation on the original air-cooled Beetle, the iconoclastic import that still warms the memories of cresting-the-hill baby boomers.

Mazda's Miata, a classic open-top sports car in the tradition of the Lotus Elan, keeps the instrument panel and interior simple.

VW is one of the few companies with enough heritage to carry off such a campaign, but it's hardly the first to attempt a revival of an icon. Mazda's Miata, refurbished for the 1999 model year, leans on the spirit of such revered British sports cars as the Lotus Elan. And even today's sport-utility vehicles are based in part on throwback design and technology that retain the spirit of the rugged World War II jeep.

Nostalgia isn't the only way to give a car a distinctive persona. The chiseled "edge" design developed for the new Mercury Cougar is largely a reaction to the overly rounded "aero" look that seemed so radical when introduced on the 1983 Ford Thunderbird. Mercury hopes to stage a revival of its own by catching the attention of a generation of enthusiasts whose gaze is clearly divided between conventional ideas of "sportiness" and the backwoods utility of pickups and SUVs.

Nostalgia sure works for Volkswagen, however. In reincarnating the Beetle, VW captures the spirit of the rear-engine, air-cooled phenomenon that hasn't been imported into the United States since 1979. But few of the details are the same.

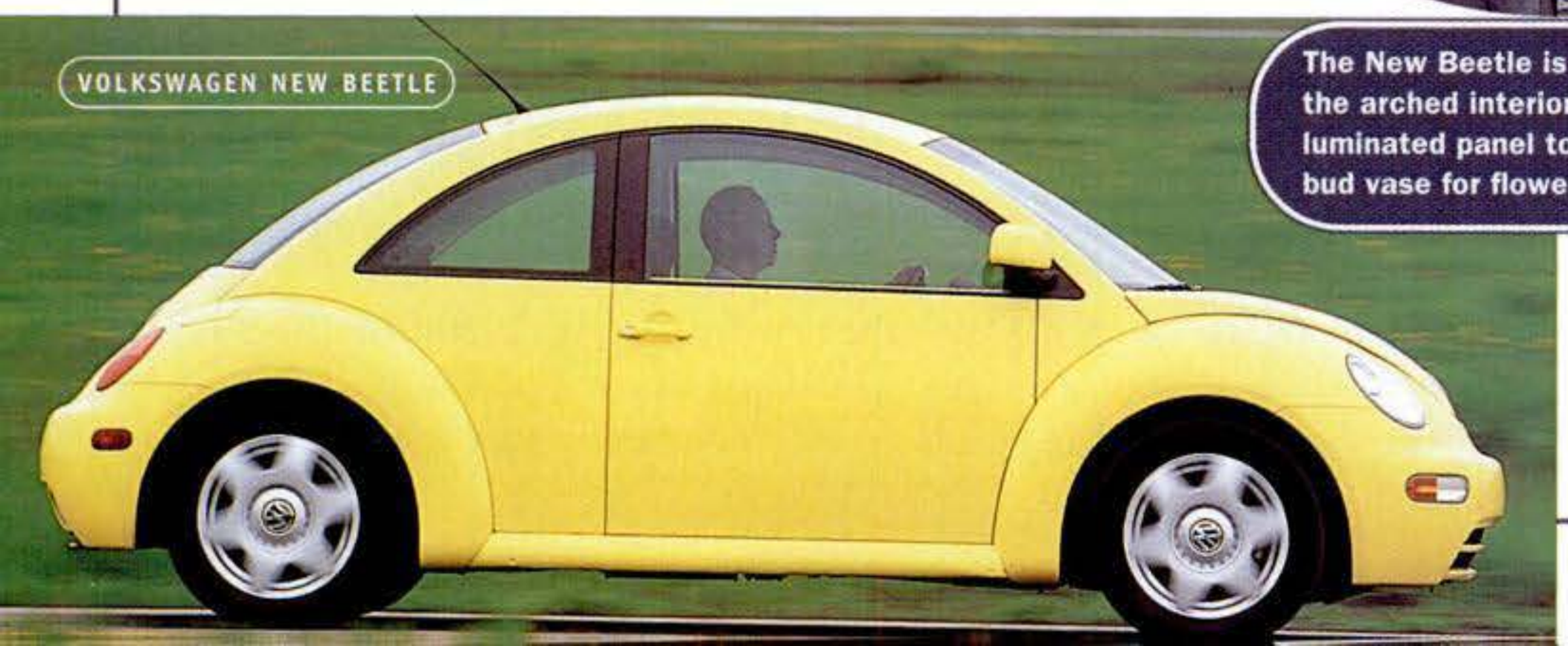
The New Beetle is based on the front-drive, transverse-engine Golf platform, using the architecture of the basic econobox that Volkswagen introduced in 1975, mainly to address the deficiencies of the old Beetle. The Bug, which was a radical engineering exercise in 1932, embodied numerous ideas that never caught on in the automotive mainstream, ranging from the engine mounted behind the rear axle to torsion bar suspension. The Golf platform had more interior room, and the front-drive car, with its transverse-mounted engine, boasted stable and predictable handling. By the mid-'70s, U.S. safety and emission standards doomed the Bug. It was unable to pass impact tests, and the engine was inefficient and difficult to outfit with emission controls.

The domed shape was the product of intuitive understanding of aerodynamics—sharp curves look smooth, but later wind-tunnel research proved them inefficient at minimizing drag. Regardless, the familiar sweep of the roofline makes the New Beetle beguiling—an inspired stroke that merges the windshield and cabin into a forward-leaning shape eager for motion.

Seductive as it is, the design creates deficiencies. Most noticeable is the restriction of forward vision—the result of the extreme forward sweep of the A-pillars framing the windshield, and the high-mounted outside mirrors. Hip room is expansive, and the arch of the roof peaks over the front seats, creating top-hat space for both the driver and passenger. The downward slope at the rear makes occupants there—even sub-six-footers—tip their heads, however. Trunk room likewise is minimal, although the rear seat folds to accommodate larger loads.

The interior is nearly as radical as the exterior—with wide surfaces of hard plastic, molded in various textures, creating a minimalist effect. The front seats are solid and supportive; the rear, less so.

The new Golf-based chassis has a strut-type front suspension, with a coil-spring, torsion-beam, trailing-arm suspension at the rear. Handling is quick and precise, although the stan-



The New Beetle is a charmer, from the arched interior to a stylized, illuminated panel topped off with a bud vase for flowers.

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The Isuzu Amigo is a serviceable, jack-of-all-trades sport-utility with a spartan interior and a removable soft top that adds flare.

dard 115-horsepower 2.0-liter four-cylinder gasoline engine takes 10 seconds from 0 to 60 mph. (A diesel is optional, and a 150-hp turbocharged option is in the works.) Braking distances on our non-ABS vehicle were longish. (ABS is available as an option.) On the highway, it is susceptible to crosswinds, a trait inherited from the Beetle's nonaerodynamic shape.

Cheerful contradiction is part of the New Beetle's charm: It's more like a sport coupe than a compact sedan, despite the absence of a traditional sport coupe shape. Carrying capacity and utility are limited, but it's loaded with curb appeal. The price starts at $15,700—hefty for a small sedan, but midrange for sport coupes.

The Cougar is as radical a departure for what has been Ford's family-car division as the New Beetle is for VW. The Cougar is a leading-edge design statement—the wide track and chiseled appearance created by horizontal folds in the steel side panels lend a distinctive road-hugging stance. Just as the New Beetle is a design study superimposed on an existing chassis, the Cougar is a striking coupe body with the transverse-drive chassis developed for the four-door Mercury Mystique underneath.

At one point in the Cougar's conception, Mercury attempted a riff on the classic two-door coupe format by adding a second set of rudimentary, rear-hinged doors that enlarged access to the rear seats. That idea never went far but underscored the interest in a fully usable four-seater. The resulting production car retains some of the sculptured appearance of the concept and finds some solutions to such drawbacks as limited passenger room and lack of rearward visibility.

The wedge-shaped profile is low-slung, but four passengers can sit comfortably—a highlight in a category that usually shortchanges at least two of them. Rear visibility through the expansive rear window and large quarter windows is good as well.

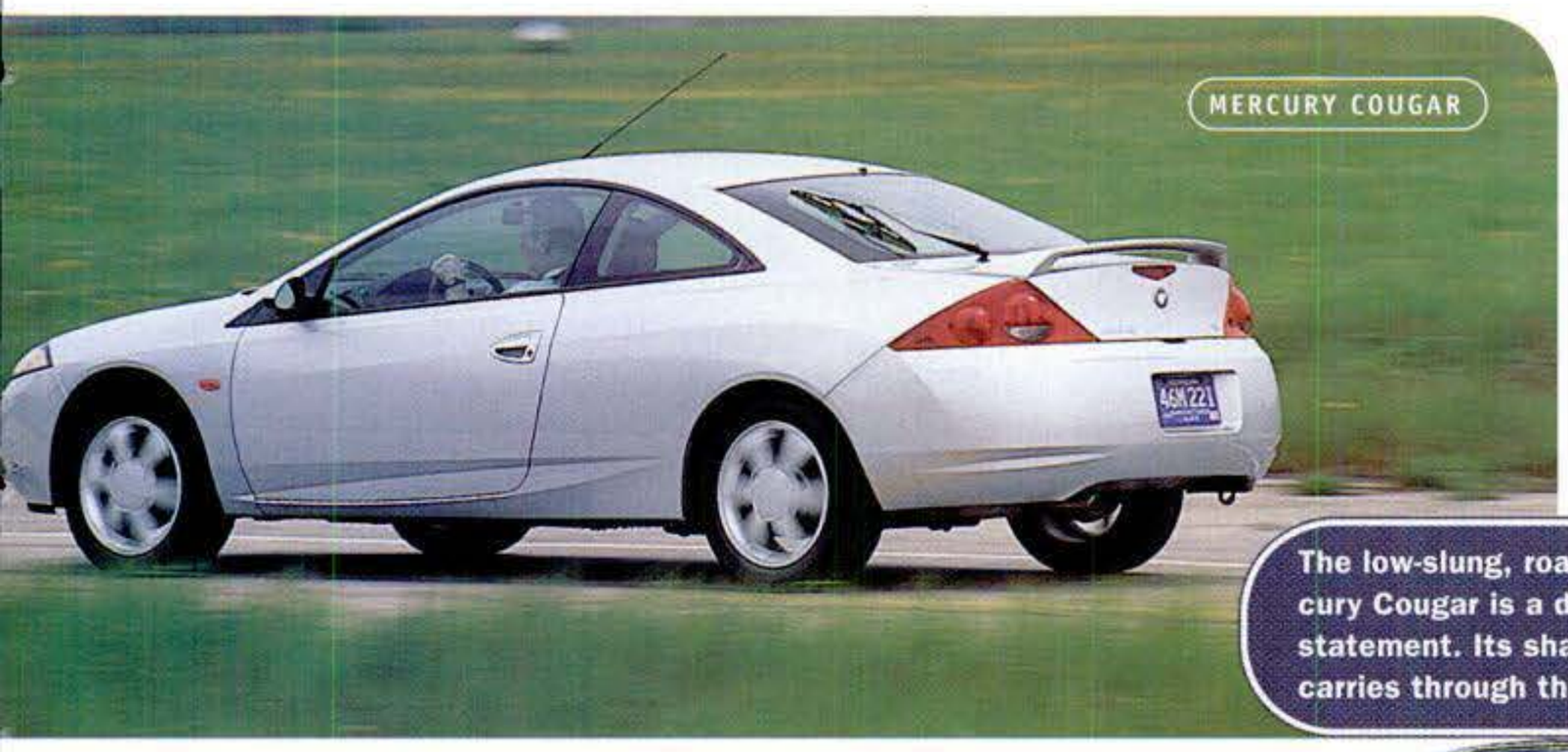
With a 106-inch wheelbase, the Cougar is slightly larger than most sport coupes. The silky-smooth 2.5-liter dohc V6 produces 170 hp, which gets it to 60 mph in 7.9 seconds. (The base engine has four cylinders.) It tends to suffer from sluggish throttle return, which makes upshifts slow and hurts throttle control in corners—apparently the result of calibrating the throttle closing to smooth upshifts. The relatively slow steering response inhibits the car somewhat on the slalom but imparts a stately feel on the highway. The net result: a high-style cruiser with an unexpectedly large and useful interior.

The Amigo is an open-top sport-utility that attempts to push all the buttons for the hard-core off-roader. The Amigo's basic platform is a four-wheel-drive, light-truck-based sport-utility with enough off-road cues to make its soft suspension something of a surprise. Wheel hop on rough surfaces results from weak shock damping and the soft spring rates, and the body leans heavily in corners.

The outboard-mounted spare tire hangs on a side-hinged rear door that should make rear access easy. But the zip-up rear curtain is awkward to remove, as is the whole soft top. Even the rear seat takes simultaneous release of catches on opposite sides to lower.

Some of this awkwardness is inherent in the rough-and-ready SUV style. But the effect is of dissonant compromise. The four-wheel-drive controls underscore the split personality. You engage 4WD via a button on the dash, while the low range gets a lever on the floor. It's confusing.

The smooth-running and powerful 205-hp 3.2-liter V6 hustles the 3,660-pound vehicle to 60 mph in a mere 8.1



The low-slung, road-hugging Mercury Cougar is a distinctive design statement. Its sharp-edged theme carries through the roomy interior.

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	MAZDA MIATA	ISUZU AMIGO		
ACCELERATION				
0-30 mph (sec.)	2.9	3.3	2.7	2.9
0-60 mph (sec.)	8.1	10.0	8.1	7.9
TOP GEAR PASSING				
30-50 mph (sec.)	8.8	9.7	9.7	9.7
50-70 mph (sec.)	10.0	10.3	10.6	9.4
HANDLING				
600-foot slalom (mph)	49.0	48.3	44.9	47.2
Double-lane change (mph)	64.8	56.6	52.8	59.0
60-0 MPH BRAKING				
Cold (ft.)	141	169	148	145
Warm (ft.)	136	146	144	136
Hot (ft.)	142	159	160	144
INTERIOR NOISE				
Idle (dBA)	49	44	44	48
60 mph (dBA)	71	65	66	67
0-60 mph (dBA)	81	74	77	77
EPA MILEAGE				
City/highway (mpg)	25/29	23/29	18/21	19/28
POWERTRAIN				
Engine	dohc 1.8-liter 4-inline	sohc 2.0-liter 4-inline	dohc 3.2-liter V6	dohc 2.5-liter V6
Valves/cylinder	4	2	4	4
Power (hp @ rpm)	140 @ 6,500	115 @ 5,200	205 @ 5,400	170 @ 6,250
Torque (ft.-lb. @ rpm)	119 @ 5,500	122 @ 2,600	214 @ 3,000	165 @ 4,250
Transmission	5-speed	5-speed	5-speed	5-speed
CHASSIS				
Front suspension	Control arms, coil springs	Strut-type, coil springs	Control arms, torsion bars	Strut-type, coil springs
Rear suspension	Control arms, coil springs	Trailing torsion beam, coil springs	Rigid axle, coil springs	Strut-type, coil springs
Brakes, f/r	Vented disc/vented disc	Vented disc/disc	Vented disc/drum	Vented disc/disc
ABS	None	None	3-channel	4-channel
DIMENSIONS				
Wheelbase (in.)	89.2	98.9	96.9	106.4
Length (in.)	155.3	161.1	168.0	185.0
Width (in.)	66.0	67.9	70.4	69.6
Height (in.)	48.4	59.5	67.0	52.2
Curb weight (lbs.)	2,360	2,820	3,660	3,080
F/r distribution (%)	53/47	64/36	54/46	64/36
Headroom (f/r in.)	37.1/NA	41.3/36.7	38.9/37.3	37.8/34.7
Legroom (f/r in.)	42.8/NA	39.4/33.0	42.1/33.3	42.6/33.2
Shoulder room (f/r in.)	49.7/NA	52.8/49.4	56.3/55.7	53.9/51.3
Passenger volume (cu. ft.)	45.7	84.3	93.7	84.4
Trunk volume (cu. ft.)	5.1	12.0	21.0	12.4
Fuel tank (gal.)	12.7	14.5	17.7	16.0
SAFETY FEATURES				
Airbags	Dual	Frontal and side	Dual	Dual
Side-impact protection	Yes	Yes	Yes	Yes
PRICES				
Base price	$20,220	$15,700	$19,795	$17,095
Price as tested	$23,530	$16,110	$20,495	$19,090
MAJOR OPTIONS	Equipment package, $2,330; floor mats, $80	Sport package, $410	16-inch wheels with P245 tires, $500; fender flares, $200	Sport group, $775; comfort group, $720; ABS, $500

VOLKSWAGEN NEW BEETLE

MERCURY COUGAR

seconds. The Amigo also has ample low-end torque for trailer towing.

In stark contrast to the ambiguous Amigo, the Miata is pure fun. Conceived as an imitation-in-spirit of classic British sports cars, it quickly established its own identity. A strict two-seater, the original Miata was a minimalist sports car with scant trunk room. Yet it soon began evolving, with power and suspension improvements. The '99 model offers a bigger trunk, stationary headlights instead of pop-ups, and a bit more power.

The Mazda still has one of the smartest manual tops, with smooth-operating catches and a glass rear window. The engine is a 140-hp 1.8-liter four-cylinder. The five-speed manual shifts with a flick of the wrist.

The high speeds posted in the slalom and double-lane change testify to its agility. Powerful brakes posted the shortest stopping time, even without ABS. But beyond the numbers, the Miata makes any road interesting —with constant feedback through the wheel and pedals, and satisfying sounds from the gearbox and exhaust. The Miata has crept up in price to more than $20,000—a bargain compared with the roadsters introduced in the past few years, but at the high end of this group of ego boosters.

The Miata may be the best value for the money among pure sports cars. This evaluation could well apply to the Cougar among other sport coupes. The two are very different, however. The Miata is an unadulterated sports car, with the accompanying limited room; the Cougar is a civilized four-seat touring coupe whose style and packaging is somewhat compromised by subdued responses.

The Isuzu Amigo fits the jack-of-all-trades SUV category reasonably well, but aside from the engine performance, it is only a middle-of-the-road effort.

The standout is the Beetle, which appears to have carved out a new niche. It is a sports car for some, a style statement for others. It is a reasonably flexible, useful car that feeds the psyche without breaking the bank. But mainly, it's lots of fun.

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Life in the Extreme

An amateur rocketeer falls from space and his rescuers turn out to be smarter than he ever imagined.

Popular Science

BONUS Section

By David Brin

CAMERAS STARE ACROSS A forbidden desert, monitoring disputed territory in a conflict so bitter that the opponents cannot even agree on what to name it.

One side calls the struggle a war with countless innocent lives in jeopardy.

The other side claims there are no victims.

And so suspicious cameras peer and pan, alert for encroachment. Vigilant camouflaged monitors scan from atop hills or under innocuous piles of stones. They hang beneath highway culverts, probing constantly for a hated enemy. For some time—months, at least—these guardians have succeeded in staving off incursions across the sandy desolation.

That is, until technology changes yet again, shifting the advantage briefly from defense to offense.

When the enemy struck this time, their first move was to take out those guardian eyes.

INFILTRATORS ARRIVED at dawn, under the glare of the rising sun. Several hundred little flying machines jetted through the air, skimming very low to the ground on gusts from whispering motors. Each device, no larger than a hummingbird, followed a carefully scouted path toward its selected target, some stationary camera or sensor. The attackers even looked like native desert birds, in case they were spotted during those crucial last seconds.

Each little drone landed behind the target, in its blind spot, and unfolded wings that transformed into high-resolution graphics displays, depicting perfect false images of the same desert scene. Each robot inserted its illusion in front of the guardian lens—carefully, so as not to create a suspicious flicker. Other small spy machines sniffed out camouflaged seismic sensors and embraced them gently, providing new cushioning that would mask the tremors to come.

The robotic attack, covering an area of more than a hundred square kilometers, took only eight minutes to complete. The desert now lay unwatched, undefended.

From over the horizon, giant vehicles started moving in. They converged along several roadways toward the same open area—17 quiet, hybrid-electric tractor trailers disguised as commercial cargo transports, complete with company holo-logos blazoned on their sides. But when their paths intersected at the chosen rendezvous, a more cryptic purpose revealed itself. Crews wearing dun-colored jumpsuits leaped from the cabs to start unlashing container sections. Auxiliary generators set to work. The air began to swirl with shimmering waves of exotic stench, as pungent volatiles gushed from storage tanks to fill pressurized vessels. Electronic consoles sprang to life, and hinged panels fell away from the trailers, revealing long, tapered objects that lay on slanted ramps.

With a steady whine, each cigar shape lifted its nose from horizontal to vertical, aiming skyward, while stabilizer fins popped open at the tail end. Shouts between the work crews grew more tense as a series of tightly coordinated countdowns commenced. There wouldn't be much time to spare before the enemy—sophisticated and wary—picked up enough clues and figured out what was going on.

About This Story

WITH THE MILLENNIUM a mere 17 months away, POPULAR SCIENCE wondered how science and technology might change life in the 21st century. Taking a cue from the turn of the last century, when famous authors like Jules Verne and H.G. Wells presented their visions **of the future, over the** next year **and a half POPULAR SCIENCE** will ask **some of today's best-known** science **fiction writers to envision life in the next 100 years, particularly in the areas most likely to see the greatest expansion of human activity: outer space, cyberspace, and inner space. Our first glimpse of the near future comes from David Brin, whose *Uplift* novels have attracted both critical acclaim and a cult following. Brin's other works have foreshadowed developments like global warming and the Internet. A 1997 movie directed by Kevin Costner was loosely based on Brin's novel *The Postman*. His 1998 nonfiction book, *The Transparent Society*, deals with the range of unexpected threats and opportunities facing society in the electronic age. Brin's vision is well-grounded in hard science; he holds a doctorate degree in space physics and is a former fellow at the California Space Institute and a researcher at the Jet Propulsion Laboratory.**

ILLUSTRATIONS BY CARY AUSTIN

Soon every missile was aimed . . . launch sequences engaged . . . and targets acquired. All they lacked were payloads.

Abruptly, a dozen figures emerged from an air-conditioned van, wearing snug suits of shimmering material and garishly painted helmets. Each one carried a small satchel that hummed and whirred, pumping air to keep the suit cool. Several had trouble walking normally. Their gait seemed rubbery, as if both excited and anxious at the same time. One of the smaller figures even briefly skipped.

A dour-looking woman wearing a badge and a uniform awaited them, holding a clipboard. She confronted the tallest figure, whose helmet bore a motif of flames surrounding a screaming mouth.

"Name and scan," she demanded in a level tone of voice.

The helmet visor swiveled back, revealing a heavily tanned face, about 30, with eyes the color of a cold sea.

"Hacker Torrey," he said, as her clipboard automatically sought his left iris, reading its unique patterns to confirm his ID. "And yes," he continued, "I affirm that I'm doing this of my own free will. Can we get on with it?"

"Your permits seem to be in order," the woman replied, unhurriedly. "Your liability bond and waivers have been accepted. The government won't stand in your way."

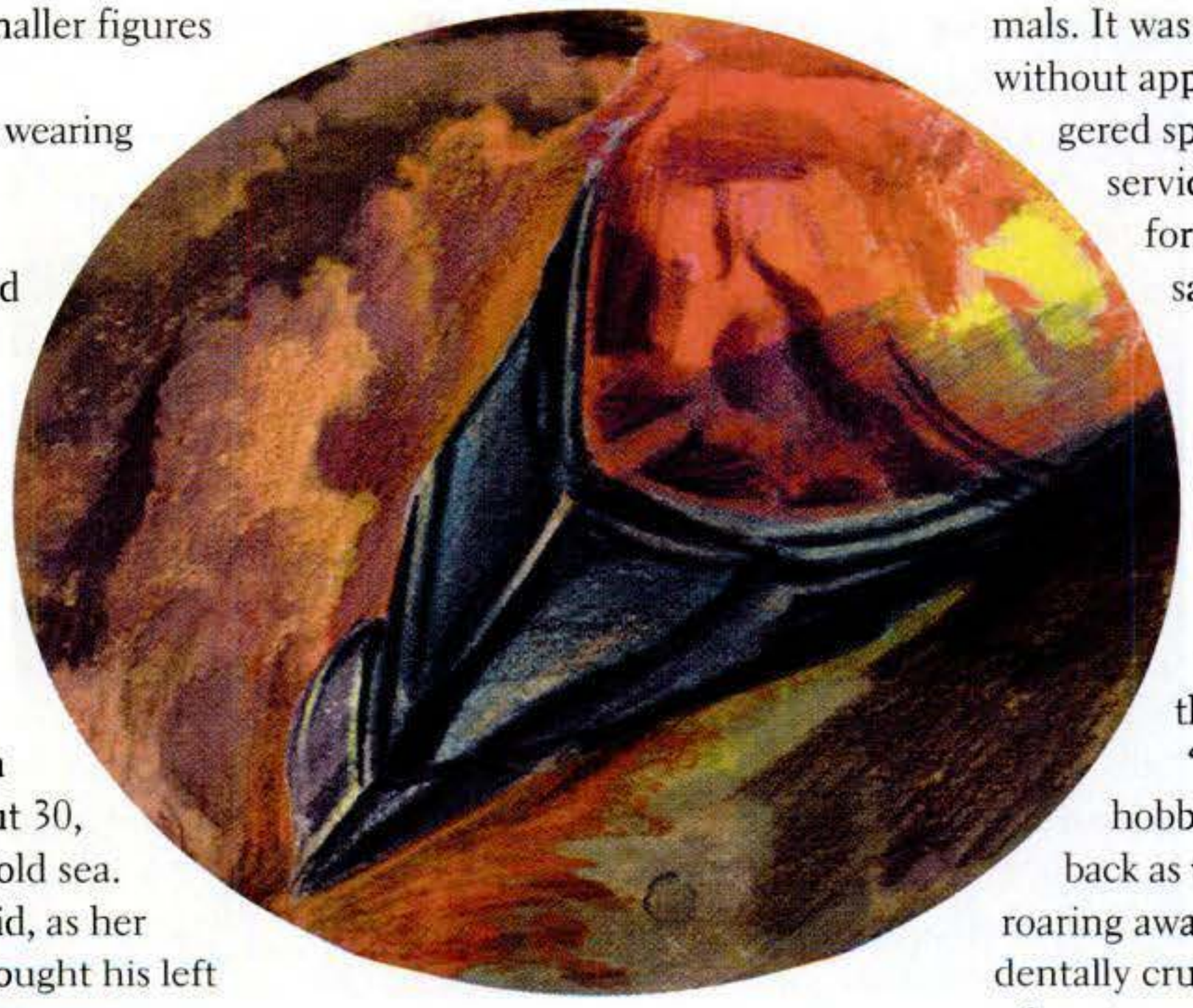
The tall man shrugged, as if the statement was both expected and irrelevant. He flung the visor back down. There were other forces to worry about, more formidable than mere government. Forces who were desperate to prevent what was about to take place here.

At a signal, all of the suited figures rushed to ladders that launch-crew members braced against the side of each rocket. Each hurried up the makeshift gantry and, slipping inside a narrow capsule, squirmed into the cramped couch with unconscious grace, having practiced the motions hundreds of times. Even the novices knew exactly what they were doing. What the dangers might be. The costs and the rewards.

Hatches slammed shut and hissed as they sealed. Muffled shouts could be heard as final preparations were completed.

The countdown for the first missile reached zero.

"Yeeeee-haw!" Hacker Torrey shouted, before a violent kick of ignition flattened him against the airbed.



He had done this several times before, yet the sheer ecstatic rush of this moment beat anything else on Earth.

Soon, he would no longer even be part of the Earth . . . for a little while.

Seconds passed amid a brutal shaking as the rocket clawed its way skyward. A mammoth hand seemed to plant itself on his chest and shove, expelling half the contents of his lungs in a moan of sweet agony. Friction heat and ionization licked the transparent nose cone just inches from his face. Shooting toward the heavens at Mach 5, he felt pinned, helplessly immobile . . . and completely omnipotent.

I'm a god!

Somehow he drew enough breath to let out another cry—this time a shout of elated greeting as black space spread before the missile's bubble nose, flecked by a million glittering stars.

Back on the ground, the last rocket was gone. Frenetic cleanup efforts then began, even more anxious than setup had been. Reports from distant warning posts told of incoming flying machines, racing toward the launch site at high speed. Men and women sprinted back and forth across the scorched desert sand, packing up to depart before the enemy arrived.

Only the government official moved languidly, using computerized scanners, meticulously adding up the damage to vegetation, erodible soils, and tiny animals. It was pretty bad, but localized, without appreciable effect on endangered species. A reconditioning service had already been called for. Of course that would not satisfy everybody. . . .

She handed over an estimated bill as the last team member revved his hybrid engine, impatient to be off. "Aw, man!" he complained, reading the total. "Our club will barely break even on this launch!"

"Then pick a less expensive hobby," she replied, and stepped back as the driver gunned his truck, roaring away in a cloud of dust, incidentally crushing one more small barrel cactus enroute to the highway. The vigilant monitoring system in her clipboard noted this and made an addendum to the excursion society's final bill.

Sitting on the hood of her jeep, she waited for another "club" to arrive. One whose members were just as passionate as the rocketeers. Just as skilled and dedicated, even though both groups hated each other. Sensors announced they were near, coming fast from the west—radical environmentalists whose no-compromise aim was to preserve nature at all costs.

The official knew what to expect when they arrived, frustrated to find their opponents gone and two acres of precious desert singed. She was going to get another tongue-lashing for being "evenhanded" in a situation where so many people insisted that you could only choose sides.

Oh well, she thought. *It takes a thick skin to work in government nowadays.*

Nobody thinks you matter much. They don't respect us like in the old days.

Looking up, she watched the last of the rocket contrails start to shear apart, ripped by stratospheric winds. For some reason it always tugged the heart. And while her intellectual sympathies lay closer to the eco-enthusiasts, a part of her deep inside thrilled each time she witnessed one of these launches. So ecstatic—almost orgiastic—and joyfully unrestrained.

"Go!" She whispered with a touch of secret envy toward the distant glitters, already arcing over the pinnacle of their brief climb and starting their long plummet toward the Gulf of Mexico.

HACKER TORREY FOUND out something was wrong just after the stars blurred out.

Flames flickered around the edges of his heat shield, probing every crevice, seeking a way inside. These flickers announced the start of re-entry, one of the best parts of this expensive ride, when his plummeting capsule would shake and resonate, filling every blood vessel with more exhilaration than you could get anywhere this side of Las Vegas. Some called this the new "superextreme hobby" . . . more dangerous than any other sport and much too costly for anybody but an elite to afford. That fact attracted some rich snobs, who bought tickets just to prove they could, and wound up puking in their respirators or screaming in terror during the long plunge back to Earth.

As far as Hacker was concerned, those fools only got what they deserved. The whole point of having money was to do stuff with it! And if you weren't meant to ride a rocket, you could always find a million other hobbies.

An alarm throbbed. He didn't hear it—his eardrums had been drugged and clamped to protect them during the flight. Instead, he felt the tremor through a small implant in his lower jaw. In a simple pulse code the computer told him.

GUIDANCE SYSTEM ERROR.

FLIGHT PATH CORRECTION MISFIRED.

CALCULATING TRAJECTORY TO NEW IMPACT ZONE.

"What?" Hacker shouted, though the rattle and roar of re-entry tore away his words. "To hell with that! I paid for a triple redundancy system—"

He stopped, realizing it was pointless to scream at the computer, which he had installed himself, after all.

"Call the pickup boats and tell them—"

COMMUNICATION SYSTEM ENCRYPTION ERROR.

UNABLE TO UPLOAD PRE-ARRANGED SPECTRUM SPREAD.

UNABLE TO CONTACT RECOVERY TEAMS.

"Override encryption! Send in the clear. Acknowledge!"

No answer came. The pulses in his jaw dissolved into a plaintive, juttering rhythm as subprocessors continued their mysterious crapout. Hacker cursed, pounding the wall of the capsule with his fist. Most amateur rocketeers spent years building their own suborbital craft, but Hacker had paid plenty for a "first class" pro model. Someone would answer for this utter incompetence!

Of course he'd signed waivers. Hacker would have little recourse under the International Extreme Sports Treaty. But there were 50,000 private investigation and enforcement services on Earth. He knew a few that would bend the uniform ethics guidelines of the Cop Guild, if paid enough in advance.

"You are gonna pay for this!" he vowed, without knowing yet who should get the brunt of his vengeance. The words were only felt as raw vibrations in his throat. Even the sonic pickups in his mandible hit their overload set points and cut out, as turbulence hit a level matching any he had ever known . . . then went beyond. *The angle of re-entry isn't ideal anymore,* he realized. *And these little sport-capsules don't leave much margin.*

I could be a very rich cinder any moment now.

The realization added a new dimension that had not been there during any of his previous amateur suborbital flights. One part of Hacker actually seemed to relish a novel experience, scraping each nerve with a howling veer past death. Another portion could not let go of the galling fact that somebody had goofed. He wasn't getting what he'd paid for.

THE WORLD STILL shook and harsh straps tugged his battered body when Hacker awoke. Only now the swaying, rocking motion seemed almost restful, taking him back to childhood, when his family used to "escape civilization" on their trimaran wingsail yacht, steering its stiff, upright airfoil straight through gusts that would topple most other wind-driven vessels.

"Idiots," Hacker's father used to grumble each time he veered the agile craft to avoid colliding with some daytripper who didn't grasp the concept of right-of-way. "The only ones out here used to be people like us, who were raised for this sort of thing. Now the robofacs make so much stuff, even fancy boats, and everybody's got so much free time. Nine billion tourists crowding everywhere. It's impossible to find any solitude!"

"The price of prosperity, dear," his mother would reply, more soft-heartedly. "At least everybody's getting enough to eat now. And there is no more talk of revolution."

"But look at the result! This mad craze for hobbies! Everybody's got to be an expert at something. The *best* at something! I tell you it was better when people had to work to survive."

"Except for people like us?"

"Exactly," Father had answered, ignoring his wife's arch tone. "Look how far we have to go nowadays just to have someplace all to ourselves."

The old man's faith in rugged self-reliance extended to the name he insisted on giving their son. And Hacker inherited—along with about a billion New Dollars—the very same quest. To do whatever it took to find someplace all his own.

As Hacker's blurry vision returned, he saw that the space pod lay tilted more than halfway over to its side. *It's not supposed to do that,* he thought. *It should float upright.*

A glance to the left explained everything. Ocean surrounded the capsule, but part of the charred heat shield was snagged on a reef of coral branches and spikes that stretched far to the distance, filled with bright fish and undulating subsea vegeta-

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tion. Nearby, he saw the parasail chute that had softened final impact. Only now, caught by ocean currents, it rhythmically tugged at Hacker's little refuge. With each surge, the bubble canopy plunged closer to a craggy coral outcrop. Soon it struck hard. He did not hear the resulting loud bang, but it made the implant in his jaw throb. Hacker winced, reflexively.

Fumbling, he released the straps and fell over, cringing in pain. That awful re-entry would leave him bruised for weeks. And yet . . .

And yet, I'll have the best story to tell. No one will be able to match it!

The thought made him feel so good, Hacker decided maybe he wouldn't take everything when he sued whoever was responsible for the capsule malfunction. Providing the pickup boats came soon, that is.

The bubble nose struck coral again, rattling his bones. A glance told him a hard truth. Materials designed to withstand launch and re-entry stresses might *not* resist sharp impacts. An ominous crack began to spread.

Standard advice was to stay put and wait for pickup, but this place would be a coffin soon.

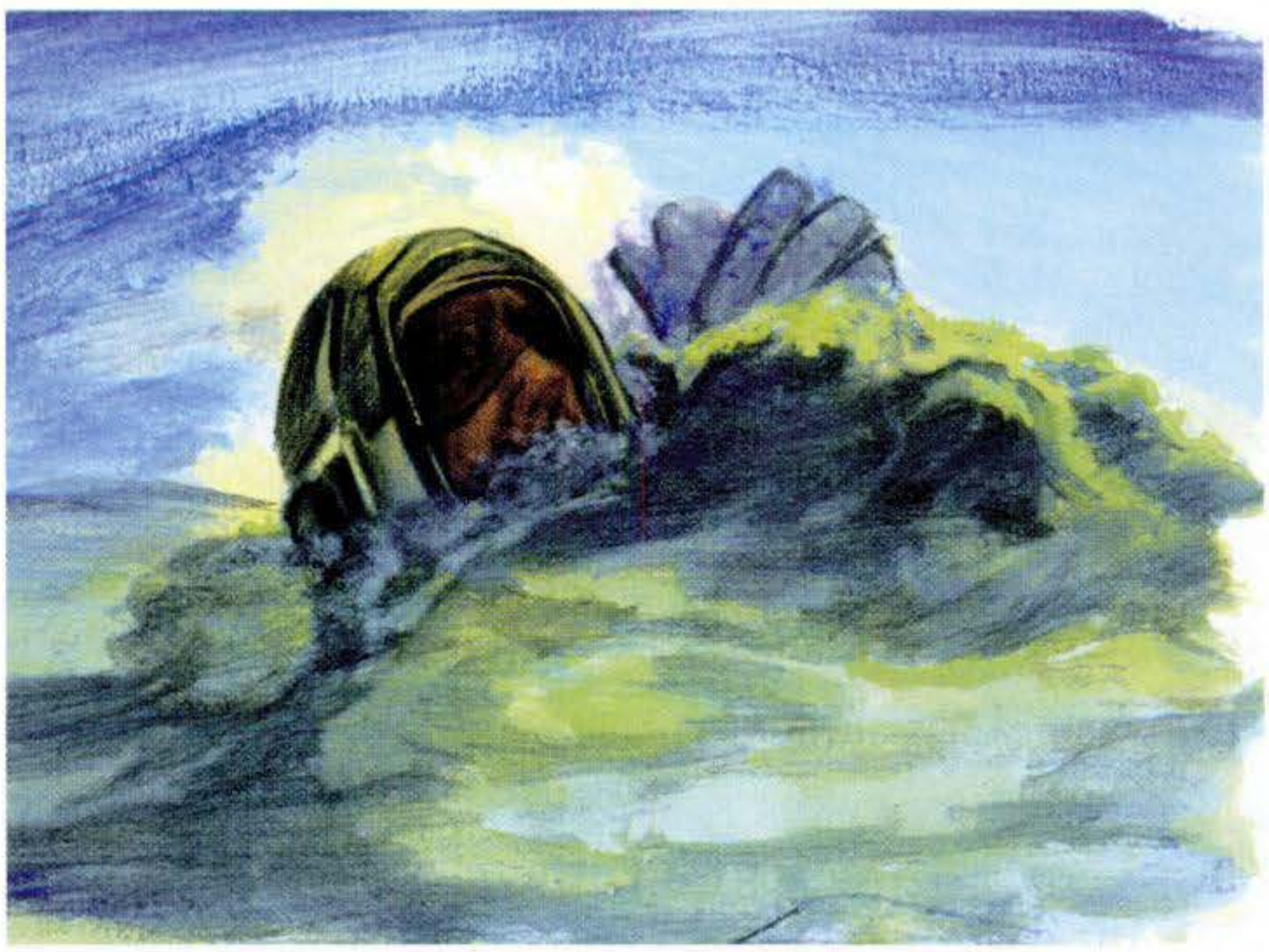
I better get out of here.

Hacker flipped his helmet shut and grabbed the emergency exit lever.

A reef should mean an island's nearby. Maybe mainland. I'll hoof it ashore, borrow someone's phone, and start dishing out hell.

ONLY THERE WAS no island. Nothing lay in sight but more horrible reef.

Hacker floundered in a choppy undertow. The skin-suit was strong, and his helmet had been made of Gillstuff—semipermeable to draw oxygen from seawater. The technology prevented drowning as currents kept yanking him down. But repeated hits by coral outcrops would turn him into hamburger meat soon.



Once, a wave carried him high enough to look around. Ocean, and more ocean. The reef must be a drowned atoll. No boats. No land. No phone.

Sucked below again, he glimpsed the space capsule, caught in a hammer-and-vice wedge and getting smashed to bits. *I'm next,* he thought, trying to swim for open water, but with each surge he was drawn closer to the same deadly site. Panic clogged his senses as he thrashed and kicked the water, fighting it like some overpowering enemy. Nothing worked, though. Hacker could not even hear his own terrified moans, though the jaw implant kept throbbing with clicks, pulses, and weird vibrations, as if the sea had noticed his plight and now watched with detached interest.

Here it comes. He turned away, knowing the next wave cycloid would smash him against those obdurate, rocky spikes.

Suddenly, he felt a sharp poke in the backside. Too early! Another jab, then another, struck the small of his back, feeling nothing like coral. His jaw ached with strange noise as someone or something started pushing him away from the coral anvil. In both panic and astonishment, Hacker whirled to glimpse a sleek, bottle-nosed creature interposed between him and the deadly reef, regarding him curiously, then moving to jab him again with a narrow beak.

This time, he heard his own moan of relief. *A dolphin!* He reached out for salvation and, after a brief hesitation, the creature let Hacker wrap his arms all around. Then it kicked hard with powerful tail flukes, carrying him away from certain oblivion.

ONCE IN OPEN water, he tried to keep up by swimming alongside his rescuer. But the cetacean grew impatient and resumed pushing Hacker along with its nose. *Like hauling an invalid.* Which he was, of course, in this environment.

Soon, two more dolphins converged from the left, then another pair from the right. They vocalized a lot, combining sonar clicks with loud squeals that resonated through the crystal waters. Of course Hacker had seen dolphins on countless nature shows, and even played tag with some once, on a diving trip. But soon he started noticing some strange traits shared by this group. For instance, these animals took turns making complex sounds, while glancing at one another or pointing with their beaks . . . almost as if they were holding conversations. He could swear they were gesturing toward him and sharing amused comments at his expense.

Of course it must be an illusion. Everyone knew that scientists had charted the limits of dolphin intelligence. They were indeed very bright animals—about chimpanzee equivalent—but had no true, human-level speech of their own.

And yet, watching a mother lead her infant toward the lair of a big octopus, he heard the baby's quizzical squeaks alternate with slow repetitions from the parent. Hacker felt sure a particular syncopated popping meant octopus.

Occasionally, one of them would point its bulbous brow toward Hacker, and suddenly the implant in his jaw pulse-clicked like mad. It almost sounded like the code he had learned, in order to communicate with the space capsule after his inner ears were clamped to protect them during flight. Hacker concentrated on those vibrations in his jaw, for lack of anything else to listen to.

His suspicions roused further when mealtime came. Out of the east there arrived a big dolphin who apparently had a fishing net snared around him! The sight provoked an unusual sentiment in Hacker—pity, combined with guilt over what human negligence had done to the poor animal. He slid a knife from his thigh sheath and moved toward the victim, aiming to cut it free.

Another dolphin blocked Hacker. "I'm just trying to help!" He complained, then stopped, staring as other members of the group grabbed the net along one edge. They pulled backward as the "victim" rolled round and round, apparently unharmed. The net unwrapped smoothly till 20 meters flapped free. Ten members of the pod then held it open while others circled behind a nearby school of mullet.

Beaters! Hacker recognized the hunting technique. They'll drive fish into the net! But how—

He watched, awed as the dolphins expertly cornered and snared their meal, divvied up the catch, then tidied up by rolling the net back around the original volunteer, who sped off to the east. *Well I'm a blue-nosed gopher,* he mused. Then one of his rescuers approached Hacker with a fish clutched in its jaws. It made offering motions, but then yanked back when he reached for it.

The jaw implant repeated a rhythm over and over. *It's trying to teach me,* he realized.

"Is that the pulse code for fish?" he asked, knowing water would carry his voice but never expecting the creature to grasp spoken English.

To his amazement, the dolphin shook its head. *No.*

"Uh," he continued. "Does it mean food? Eat? Welcome stranger?"

An approving blat greeted his final guess, and the Tursiops flicked the mullet toward Hacker, who felt suddenly ravenous. He tore the fish apart, stuffing each bit of it through his helmet's chowlock.

Welcome stranger? He pondered. *That's mighty abstract for a dumb beast to say. Though, I'll admit, it's friendly.*

THAT DAY PASSED, and then a tense night that he spent clutching a sleeping dolphin by moonlight while clouds of phosphorescent plankton drifted by. Fortunately, the same selective-permeability technology that enabled his helmet to draw oxygen from the sea also provided a trickle of fresh water, filling a small reservoir near his cheek. *I've got to buy stock in this company,* he thought, making a checklist for when he was picked up tomorrow.

Only pickup never came. The next morning and afternoon passed pretty much the same, without catching sight of land or boats. *The world always felt so crowded,* he thought. *Now it seems endless and unexplored.*

Hacker started earning his meals by helping to hold the fishing net when the group harvested dinner. The second night he felt more relaxed, dozing while the dolphins' cliquey gossip seemed to flow up his jaw and into his dreams. On the third morning, and each of those that followed, he felt he understood just a bit more of their simple language.

He lost track of how many days and nights passed. Slowly, Hacker stopped worrying about where the pickup boats could be. Angry thoughts about lawsuits and revenge rubbed away under relentless massaging by current and tide. Immersed in the dolphins' communal sound field, he began concerning himself instead with daily problems of the tribe, like when two young males got into a fight, smacking each other with their beaks and flukes until adults had to forcibly separate them. Using both sign language and his growing vocabulary of click-code, Hacker learned that a female (whose complex name he shortened to Chee-Chee) was in heat. The young brawlers held little hope of mating with her. Still, their nervous energy needed an outlet. At least no one had been seriously harmed.

An old-timer—Kray-Kray—shyly presented a pectoral fin to Hacker, who used his knife to dig out several wormlike parasites. "You should see a real doctor," he urged, as if one gave verbal advice to dolphins every day.

Helpers go away, Kray-Kray tried to explain in click code. *Fins need hands. Helper hands.*

It supported Hacker's theory that something had been done to these creatures. An alteration that had made them distinctly different from others of their species. But what? The mystery grew each time he witnessed some behavior that just couldn't be natural.

Then, one day the whole tribe grew excited, spraying nervous clicks everywhere. Soon Hacker saw they were approaching an undersea habitat dome hidden in a narrow canyon, near a coast where waves met shore.

Shore. The word tasted strange after all these days—weeks?—spent languidly swimming, listening, and learning to enjoy raw fish. Time had different properties down here. It felt odd to contemplate leaving this watery realm, returning where he clearly belonged—the surface world of air, earth, cities, machines, and 9 billion humans, forced to inhale one another's humid breath everywhere they went.

That's why we dive into our own worlds. Ten thousand hobbies. A million ways to be special, each person striving to be expert at some arcane art . . . like rocketing into space. Psychologists approved, saying that frenetic amateurism was a much healthier response than the most likely alternative—war. They called this the Century of Aficionados, a time when governments and professional societies could not keep up with private expertise, which

spread at lightning speed across the WorldNet. A renaissance, lacking only a clear sense of purpose.

The prospect of soon rejoining that culture left Hacker pensive. *What's the point of so much obsessive activity, unless it leads toward something worthwhile?*

The dolphins voiced a similar thought in their simple but expressive click-language.

If you're good at diving—dive for fish!

If you have a fine voice—sing for others!

If you're great at leaping—bite the sun!

Hacker knew he should clamber up the nearby beach now to call his partners and brokers. Tell them he was alive. Get back to business. But instead he followed his new friends to the hidden habitat dome. *Maybe I'll learn what's been done to them, and why.*

Swimming under and through a portal pool, he was surprised to find the place deserted. No humans anywhere. Finally, Hacker saw a hand-scrawled sign.

PROJECT UPLIFT SUSPENDED!
WE RAN OUT OF CASH.
COURT COSTS ATE EVERYTHING.
THIS STRUCTURE IS DEEDED TO OUR FINNED FRIENDS.
BE NICE TO THEM.
MAY THEY SOMEDAY JOIN US AS EQUALS.

There followed a WorldNet access number, verifying that the little dolphin clan actually owned this building, which they now used to store their nets, toys, and a few tools. But Hacker knew from their plaintive calls the real reason they kept coming back. Each time they hoped to find that their "hand-friends" had returned.

Unsteady on rubbery legs, he crept from the pool to look in various chambers. Laboratories, mostly. In one, he recognized a gene-splicing apparatus made by one of his own companies.

Project Uplift? Oh yes. I remember hearing about this.

It had been featured in the news, a year or two ago. Both professional and amateur media had swarmed over a small group of "kooks" whose aim was to alter several animal species, giving them human-level intelligence. Foes of all kinds had attacked the endeavor. Religions called it sacrilegious. Eco-enthusiasts decried meddling in nature's wisdom. Tolerance-fetishists demanded that native dolphin "culture" be left alone, while others worked to scuttle the proposal, predicting mutants would escape the labs to endanger humanity.

One problem with diversity in an age of amateurs was that your hobby might attract ire from a myriad of others, especially those whose particular passion was indignant disapproval, with a bent for litigation.

Project Uplift could not survive the rough-and-tumble battle that ensued. A great many modern endeavors didn't.

Survival of the fittest, he mused. *An enterprise this dramatic and controversial has to attract strong support or it's doomed.*

He glanced back at the pool, where members of the tribe had taken up a game of water polo, calling fouls and shouting at one another as they batted a ball from one goal to the next, keeping score with raucous sonar clicks.

Hacker wondered. Would the "uplift" changes carry through from one generation to the next? Could this new genome spread among wild dolphins? If so, might the project have already succeeded beyond its founders' dreams, or its detractors' worst nightmares?

What if the work resumed, finishing what got started here? If other species speak and start creating new things, will they be treated as equals—as co-members of our civilization—or as the next discriminated class?

Some critics were probably right. For humans to attempt such a thing would be like an orphaned and abused teen trying to foster a wild baby. There were bound to be mistakes and tragedies along the way.

Are we wise enough?

It wasn't the sort question Hacker used to ask himself. He felt changed by his experience at sea. At the same time, he realized that just asking the question was part of the answer.

Maybe it'll work both ways.

His father would have called that "romantic nonsense." And yet . . .

Exploring one of the laboratories, Hacker found a cheap but working phone that someone had left behind—then had to work at a lab bench for an hour, modifying it to tap the sonic implant in his jaw. He was about to call his manager and broker—before they had a chance to declare him dead and start liquidating his empire. But then Hacker stopped.

He paused, then keyed the code for his lawyer instead.

At first Gloria Bickerton could not believe he survived. She wouldn't stop shouting with joy. *I didn't know anyone liked me that much,* he mused, carrying the phone back to the dome's atrium. He arrived in time to witness the water polo game conclude in a frothy finale.

"Before you arrange a pickup, there's something I want you to do for me," he told Gloria, after she calmed down. Hacker gave her the WorldNet codes for Project Uplift and asked her to find out everything about it, including the current disposition of its assets and technology—and how to contact the experts whose work had been interrupted here.

Gloria asked him why. He started to reply.

"I think I've come up with a new . . ."

Hacker stopped there, having almost said the word "hobby." But suddenly he realized that he had never felt this way about anything before. Not even the exhilaration of rocketry. For the first time he burned with a real ambition. Something worth fighting for.

In the pool, several members of the tribe were now busy winding their precious net around the torso of the biggest male, preparing to go foraging again. Hacker overheard them gossiping as they worked, and chuckled when he understood one of their crude jokes. A good natured jibe at his expense.

Well, a sense of humor is a good start. Our civilization could use more of that.

"I think," he resumed telling his lawyer, "I think I know what I want to do with my life." ◆

FYI

EDITED BY CECILIA WESSNER

Research by Chris O'Malley, Gunjan Sinha, and Frank Vizard

ASK POPULAR SCIENCE

What makes glow-in-the-dark plastics glow?

Lorenzo Perez
Miami Lakes, Fla.

DIFFERENT companies mix different compounds into molten plastics to make them glow, and most will not reveal exact chemical constituents. All of the compounds, however, share the property of absorbing light and then reemitting it as, for example, the fluorescent green found in glow-in-the-dark Frisbees and alarm clocks. One common compound is a mixture of zinc sulfide, copper, and sodium fluorescein. Light excites electrons within the zinc sulfide, causing it to emit blue-violet light. This light is absorbed by the sodium fluorescein, which reemits the light as fluorescence.

Years ago, companies used radioactive substances to make plastics glow. Such substances have since been abandoned, and today all fluorescent compounds are nontoxic.

What is a neural network?

Augm87b@Prodigy.com

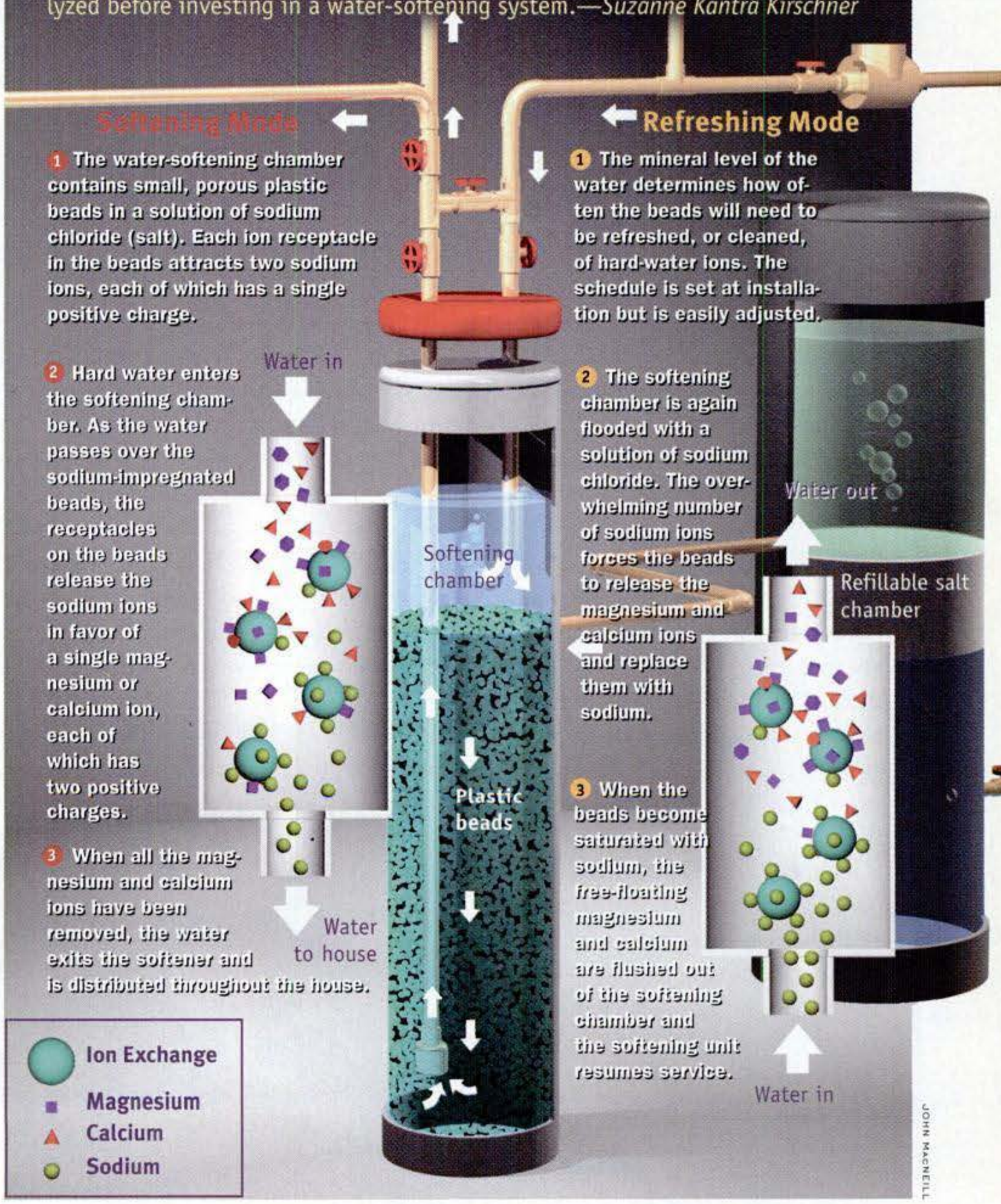
THERE ARE MANY types of neural networks, but broadly speaking, they are networks of computer processors and software (within one machine or many) that attempt to imitate a system of biological neurons—often the human brain in particular.

Neural nets use techniques modeled after the behavior of biological neurons so as to "learn" from the feedback they are given, discern patterns

HOW IT WORKS

Ion-Exchange Water Softeners

IF YOU HAVE CALCIUM AND MAGNESIUM in your water supply, you have what's known as hard water. While these minerals aren't harmful, they can encrust your pipes, bathroom fixtures, and cooking pans. Ion-exchange water softeners eliminate these minerals, but might not be effective if your water also contains high levels of chlorides, sulfates, or iron. So be sure to have your water analyzed before investing in a water-softening system.—*Suzanne Kantra Kirschner*



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THE FACTS

Rings of Fire

ONCE CONSIDERED TO REPRESENT the fiery wrath of gods gone mad, erupting volcanoes have been both feared and revered by civilizations throughout history. The mythologies of Greeks, Romans, Indonesians, Japanese, Icelanders, and Hawaiians all contain accounts of gods or goddesses whose anger was manifested in the eruption of a volcano. We now know that these mountains of spitting fire are actually giant vents through which Earth relieves the enormous amount of heat and pressure that's brewing within its molten core.—*compiled by Gunjan Sinha*

Volcanoes occur because molten rock, or magma, is less dense than the surrounding solid rock. Thus, it tends to rise. As magma nears the surface, dissolved gases—sulfur, steam, and carbon dioxide—expand as they boil out of the molten rock, propelling the lava, ashes, cinders, and blocks of rock out through the vent.

STROMBOLIAN ERUPTIONS ARE NAMED after the island of Stromboli, which is located off the southwest coast of Italy. Unlike slow-oozing lava flows from long fissures, Strombolian eruptions shoot out of a subsurface pipeline. They form steep conical mountains and are known for their constant explosions, which can occur as often as every 15 to 20 minutes.

Hawaii's islands, unlike most volcanoes, were not formed by plate tectonics. Instead, molten rock beneath the ocean was coughed out over millions of years and eventually hardened into solid rock. Areas not far below Earth's surface that contain molten rock are called geological hot spots.

Peléan eruptions describe extremely destructive activity. Named after the historic eruption of Mont Pelée in 1902 in the Caribbean port of St. Pierre, Peléan eruptions can generate avalanches of glowing volcanic ash. The ash can pour down the steep banks of a volcano at more than 60 mph.

PLATE TECTONICS ensure that most volcanoes exist as long chains or belts that form arcs. Why? Earth's crust is made up of a dozen or so plates, all some 30 to 60 miles thick. These plates move horizontally, crashing into one another at some points, separating at others. This movement, in turn, creates zones of molten rock between the plates that are pushed toward the surface. Most of the world's 800-plus known volcanoes are found within these between-plate boundaries, and three-quarters of them exist in a single chain known as the Ring of Fire that surrounds the Pacific Ocean. Indeed, hundreds of volcanoes are likely to be hidden beneath the world's oceans.

1 million people, probably more, in the past 2,000 years have been killed by violent mud slides and lava flows following volcanic activity. Most of these deaths have been caused by a few violent eruptions. For example, two volcanoes in Indonesia—Tambora in 1815 and Krakatau in 1883—together killed 120,000 people. In 1985, mud flows from Ruiz volcano in Armero, Columbia, caused 25,000 deaths.

CLASSIFICATION OF a volcano depends on its shape, size, and characteristic type of eruption. Icelandic volcanoes, for example, pour out molten lava from fissures approximately 16 miles long. Expanding gases often form lava fountains that spew from these fissures.

VULCANOLOGISTS TODAY CAN USUALLY predict an impending blast by using sensitive equipment to monitor molten rock as it moves to the surface; following and recording earthquake patterns in the area; and studying the composition of gases emanating from the volcano.

Romans believed that the constant rumblings on the island of Vulcano, located off the southwest coast of Italy, represented the rage of Vulcan—the god of fire and maker of weapons. Hence, the word "volcano" was coined.

212 North American volcanoes have been active within the past 10,000 years, giving this land mass—comprising the area from Alaska south to the Panama Canal—more live volcanoes than any other continent. Indonesia ranks second among geographic areas with 127 active volcanoes.

GEORGE PHILIP LTD.

WRITTEN ACCOUNTS of eruptions dot history. The earliest comes from a painting in Catal Huyuk, Turkey, dating to 6200 B.C. The first written eyewitness account was in 79 A.D.; in a letter, Roman Pliny the Younger described the eruption of Vesuvius—which buried Pompeii.

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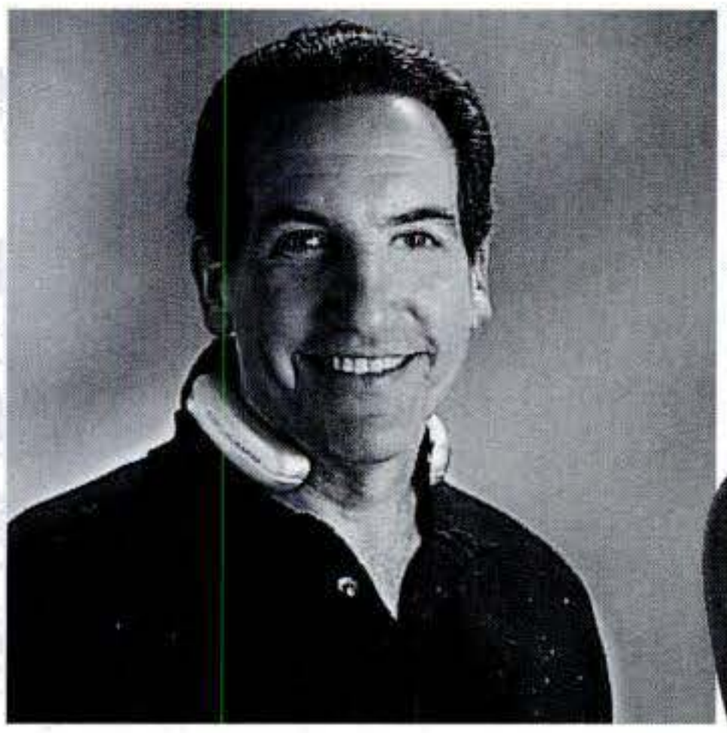

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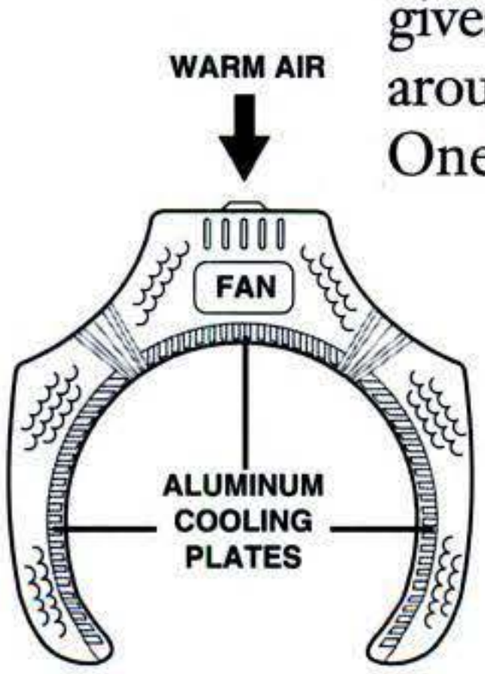

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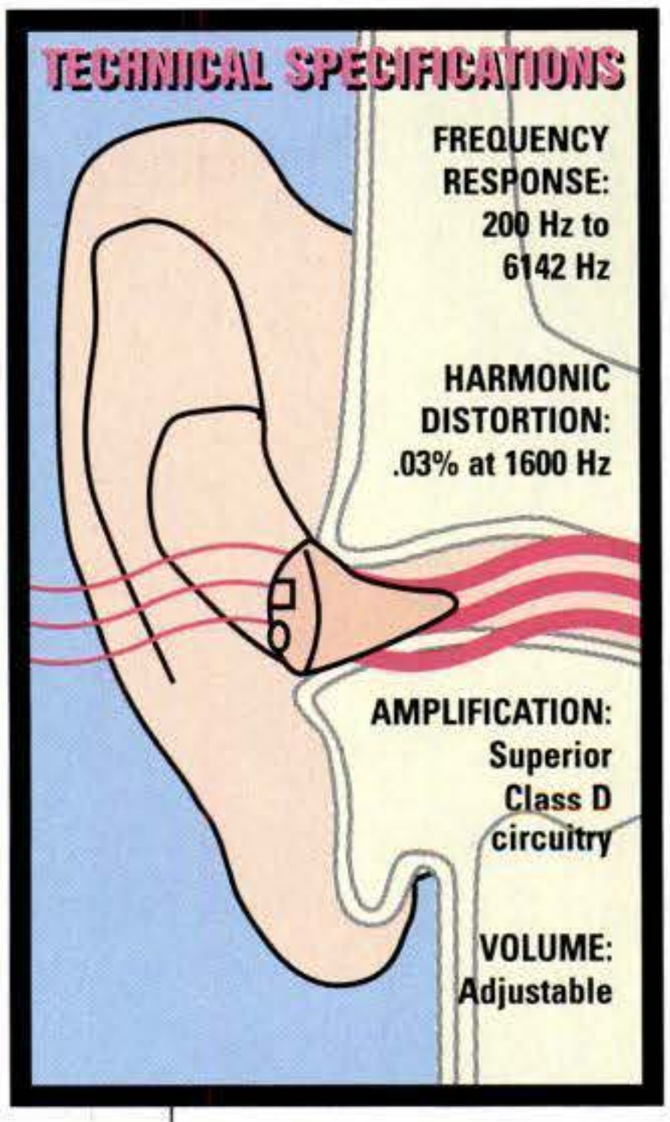
TECHNOLOGY UPDATE

One scientist's vision revolutionizes the hearing industry, benefiting millions of people...

Crystal Ear® uses sophisticated electronics to provide affordable, cosmetically-pleasing and easy-to-use hearing amplification.

One day a friend asked my wife Jill if I had a hearing aid. "He certainly does," replied Jill, "Me!" After hearing about a remarkable new product, Jill finally got up the nerve to ask me if I'd ever thought about getting a hearing aid. "No way," I said. "It would make me look 20 years older and cost a fortune." "No, no," she replied. "This is entirely different. It's not a hearing aid...it's Crystal Ear!"

No one will know. Jill was right. Crystal Ear *is* different—not the bulky, old-styled body-worn or over-the-ear aid, but an advanced personal sound system so small it's like contacts for your ears. And Crystal Ear is super-sensitive and powerful, too. You will hear sounds your ears have been missing for years. Crystal Ear will make speech louder, and the sound is pure and natural.



Innovative, breakthrough technology solves common problem...

Hearing loss, which typically begins prior to teenage years, progresses throughout one's lifetime. Nearly 90 percent of people suffering the type of loss Crystal Ear was designed for choose to leave the problem untreated. Crystal Ear is now available to help these people treat their hearing loss with a small and very affordable Class I in-the-canal hearing amplifier.

I couldn't believe how tiny it is. It is smaller than the tip of my little finger and it's almost invisible when worn. There are no wires, no behind-the-ear devices. Put it in your ear and its ready-to-wear mold fits comfortably. Since it's not too loud or too tight, you may even forget that you're wearing it! Use it at work or at play. And if your hearing problem is worse in certain situations, use Crystal Ear only when you need it.

A fraction of the price. Hearing loss is the world's number-one health problem, but in most cases it goes completely untreated. For many millions of people, hearing devices are way too expensive, and the retail middlemen want to keep it that way. What's more, treating hearing loss the old retail way can involve numerous office visits, expensive testing and adjustments to fit your ear. Thanks to Crystal Ear, the "sound solution" is now affordable and convenient. Almost 90% of people with mild hearing loss, and millions more with just a little hearing dropoff, can be dramatically helped with Crystal Ear. Plus, its superior design is energy-efficient, so batteries can last months, not just weeks.

You'll feel years younger! Wear Crystal Ear indoors, outdoors, at home and at work. Crystal Ear arrives ready to use, complete with batteries, two different fitting sleeves, a cleaning brush and even a carrying case. Crystal Ear is a breakthrough advance in the hearing device field. It is made in the USA, using state-of-the-art micro-manufacturing techniques that cut costs dramatically—savings that we can pass on to you. The conventional companies, domestic and foreign, don't like that!

Don't be fooled by high prices. No hearing device, no matter how expensive, can eliminate background noise, despite claims by the manufacturers. Crystal Ear does not promise miracles—just an affordable, sound solution to many common hearing problems.

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	MOST IN-CANAL BRANDS	CRYSTAL EAR
Require fitting	Yes	No
Require testing	Yes	No
Battery life	160 hours	320 hours
Impact resistance	Average	Excellent
Whistling/feedback	Frequent	Limited
Telephone use	Yes	Excellent
Retail price	$1,000-2,000	$299.85

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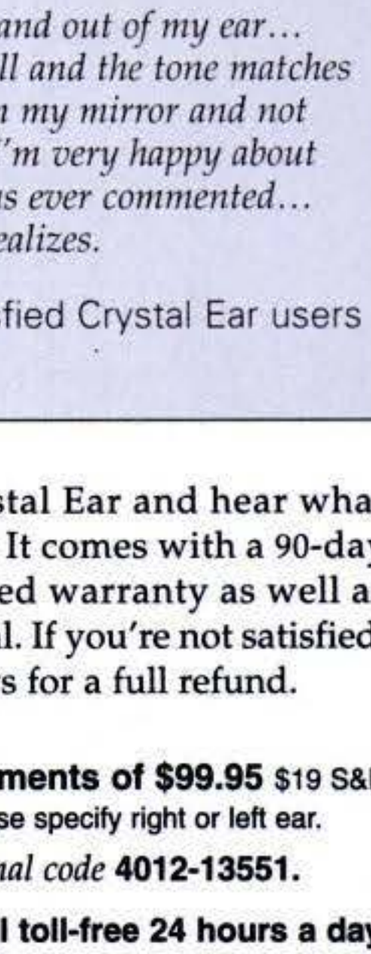

"My father spent over $5000 on another brand. I showed him my Crystal Ear, he tried it, and he decided it worked better than his brand, even though it was a small fraction of the cost!"

"It's so easy to put in and out of my ear... I just twist it. It's small and the tone matches my ear, so I can look in my mirror and not even see it in my ear. I'm very happy about that. In fact, no one has ever commented... I don't think anyone realizes.

—Satisfied Crystal Ear users

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from information, and solve problems based on what they encounter. Some of the most ambitious neural net systems attempt to mimic our ability to make decisions or interact with other humans; this imitation is often referred to as artificial intelligence. Others are used for more practical applications, such as speech recognition, robotics, and weather or stock-market forecasting.

Why does my position in a room affect my stereo's FM reception?

Daniel Bergman
Stillwater, Okla.

TWO FACTORS may be coming into play. First, FM signals are directional, so if you're between the stereo's antenna and the transmitting tower, you'll partially block the signal. Second, the human body consists mostly of water, which serves as a fairly good antenna and may affect the signal-receiving capability of your stereo.

To avoid interference of this type, you might try sticking your stereo antenna out a nearby window.

How do touch lamps work?

nhamra@juno.com

ALL TOUCH LAMPS use the same mechanism, in which an oscillating coil emits a high-frequency signal that is transmitted over the metal surfaces of the lamp. If you touch the metal, usually on the lamp base, you squelch the frequency. A sensor picks up this change in frequency, and turns on the lamp. When you touch the lamp once, it illuminates at 10 percent of its capacity. A second touch brings the level to 40 percent, while a third tap brings the lamp to full capacity.

Although first patented and manufactured on a small scale in 1956 by Aladdin Industries, in Nashville, Tennessee, touch lamps were only widely manufactured after 1980. That year, a company called Westek, in San Diego, marketed a unique sensing system that could be easily wired into table and floor lamps, building on a patent the company received for the technology in 1978. Today, Westek licenses the technology to several lamp manufacturers.

Converters that enable you to turn traditional lamps into touch-sensitive models are also available through Westek. For more information, call 800-331-3366. ◆

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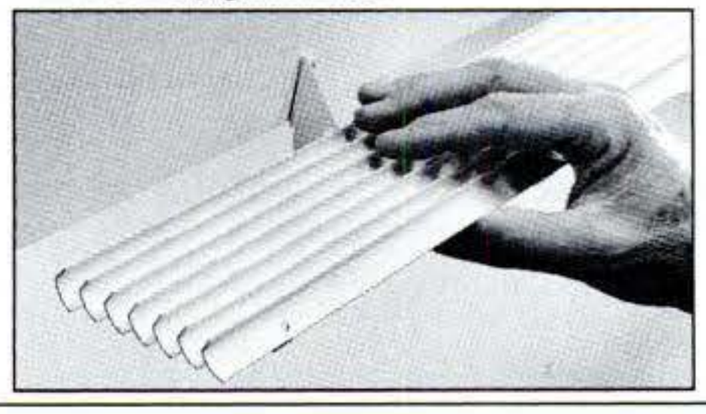

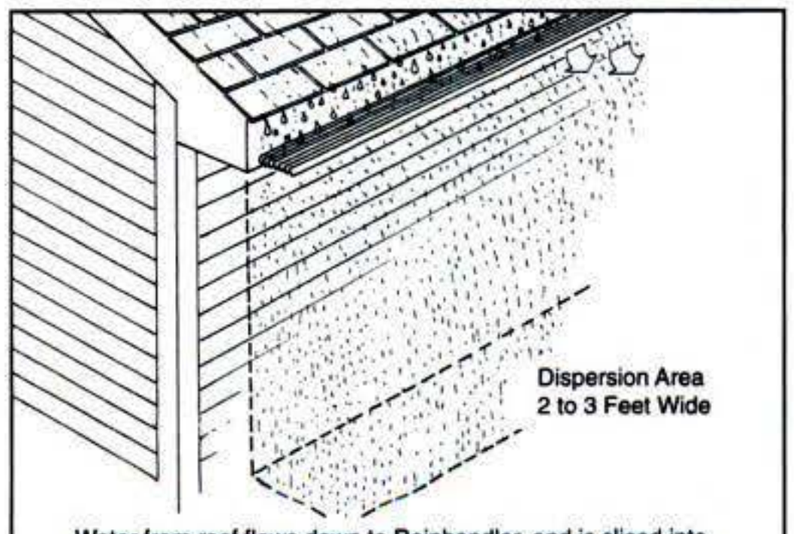

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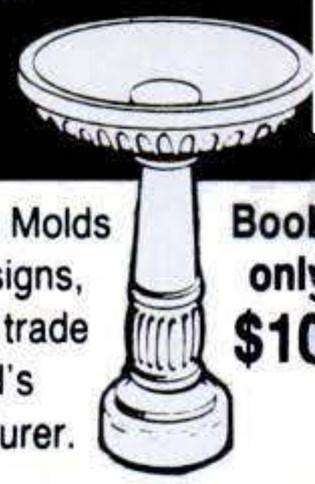

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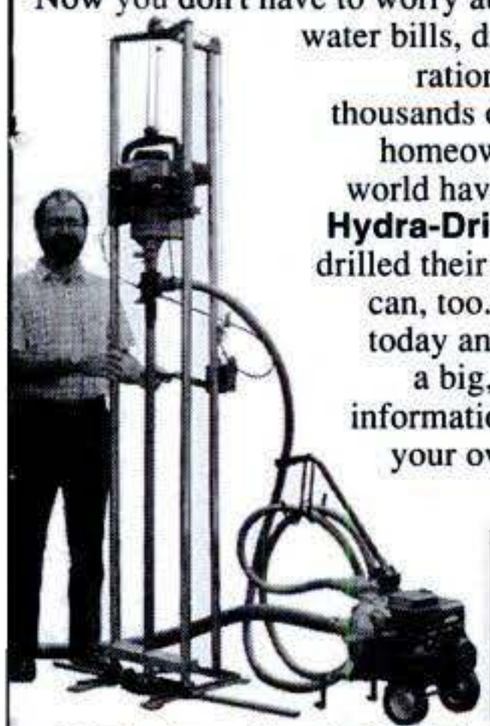

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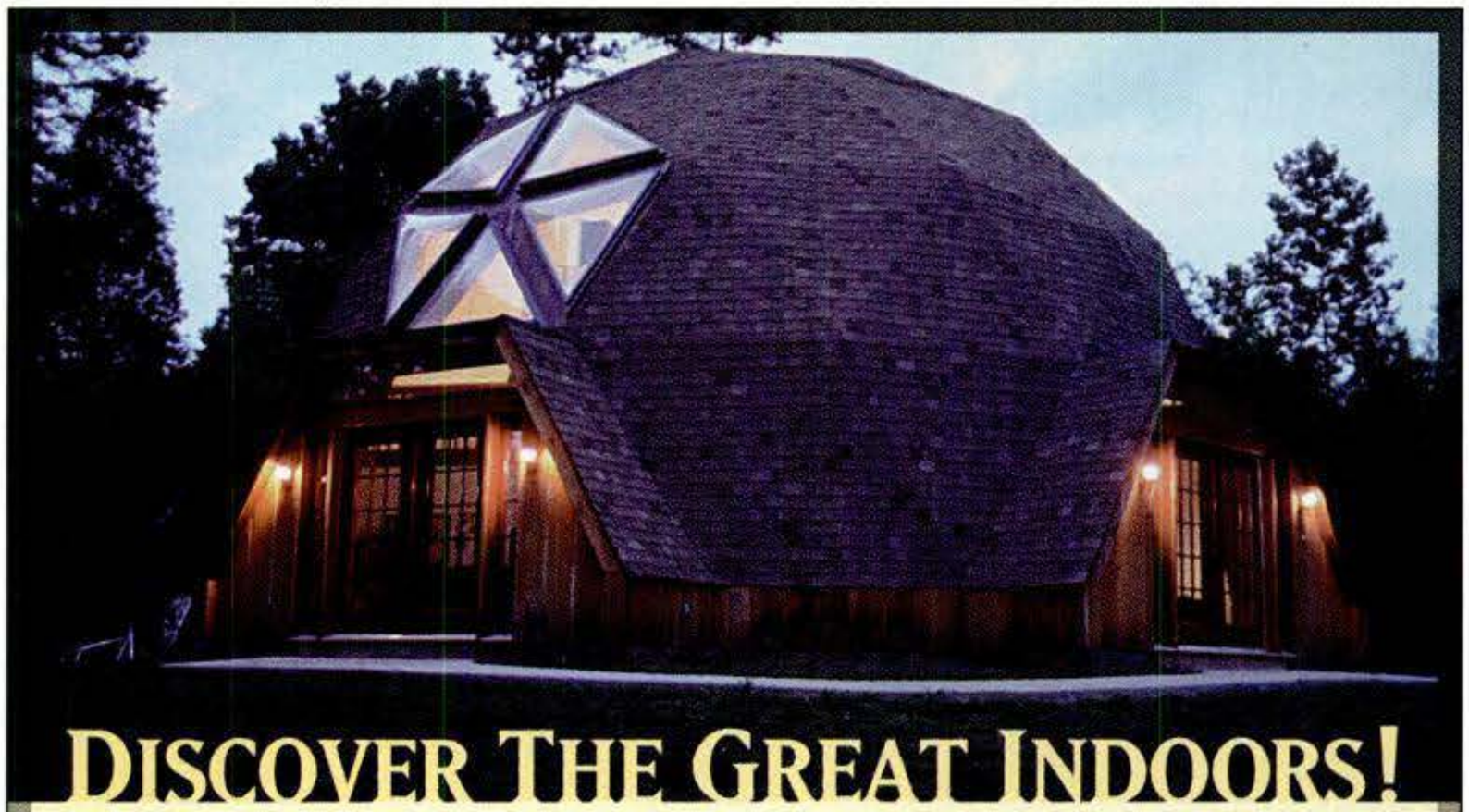

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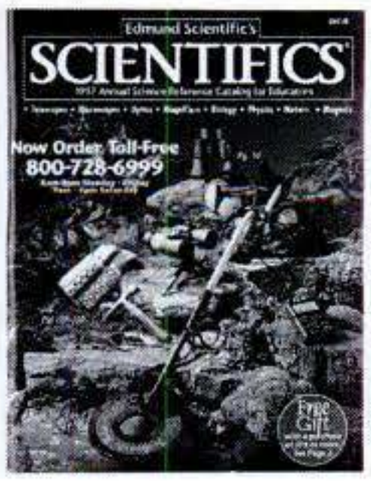

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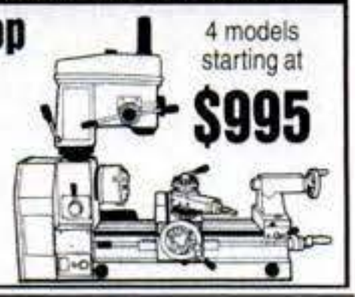

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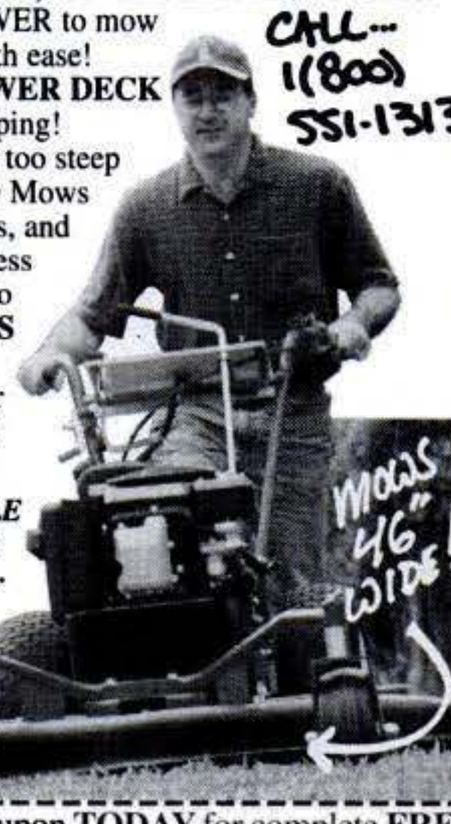

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Continued from pg. 95

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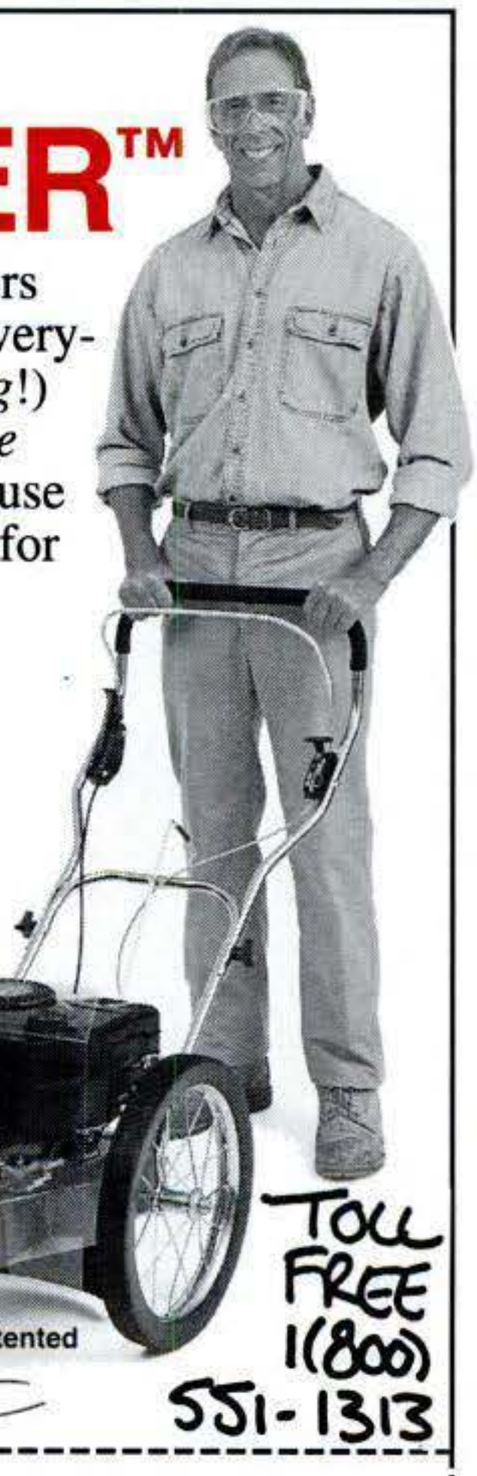

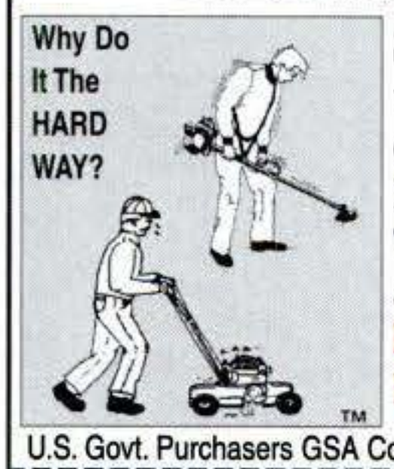

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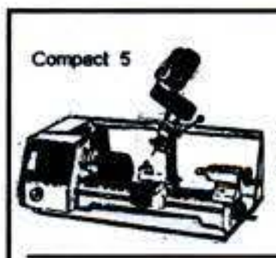

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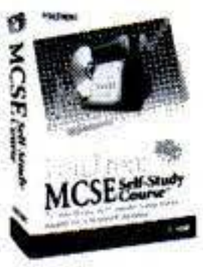

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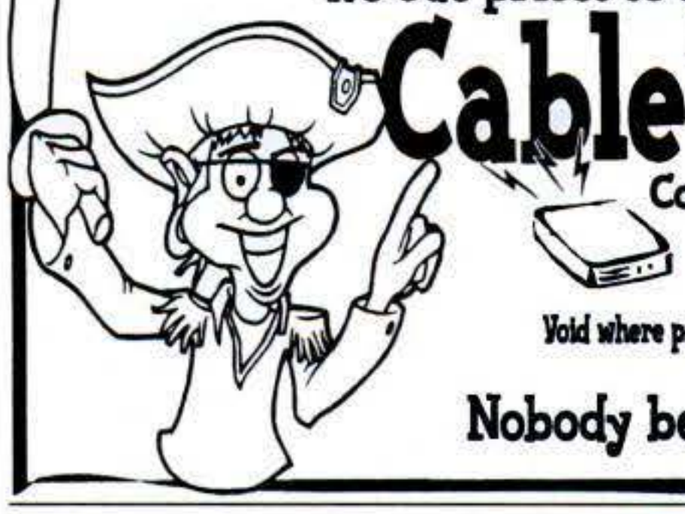

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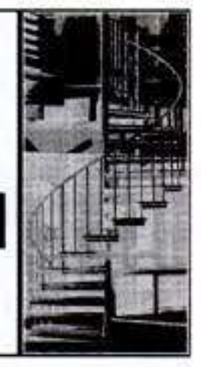

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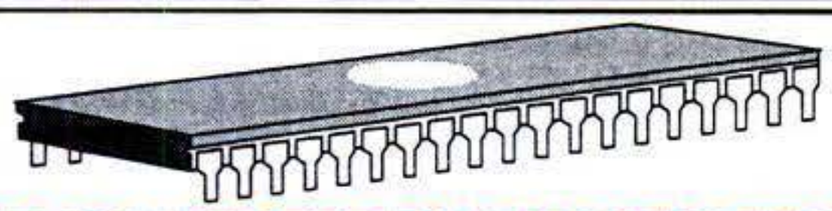

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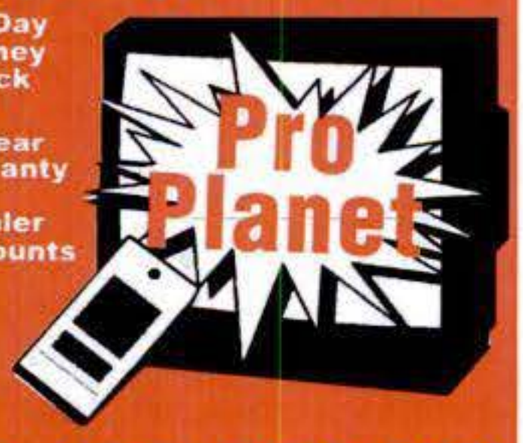

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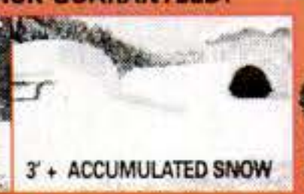

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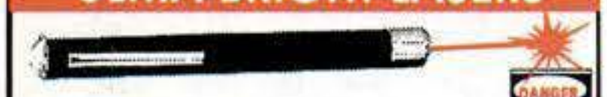

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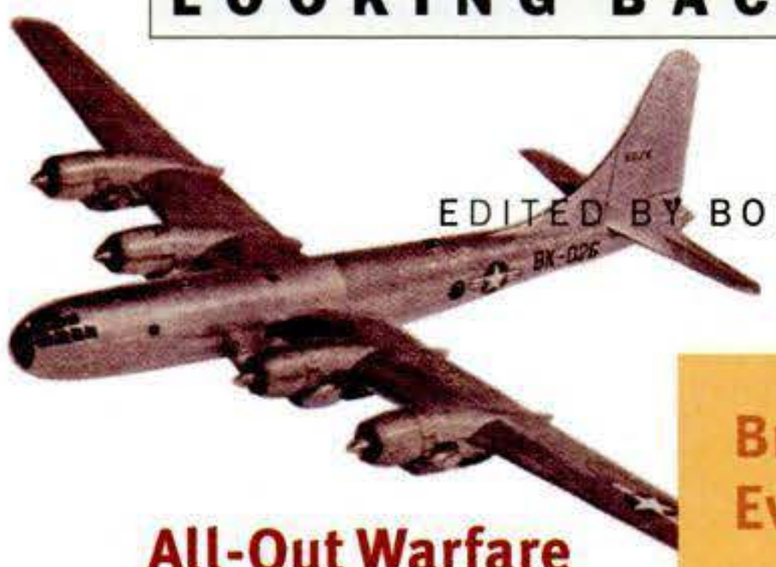

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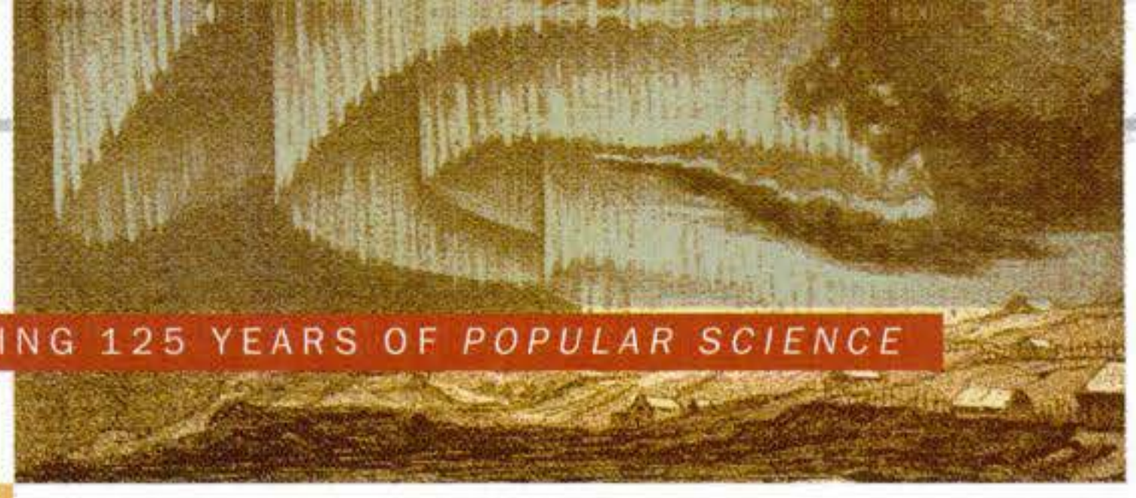
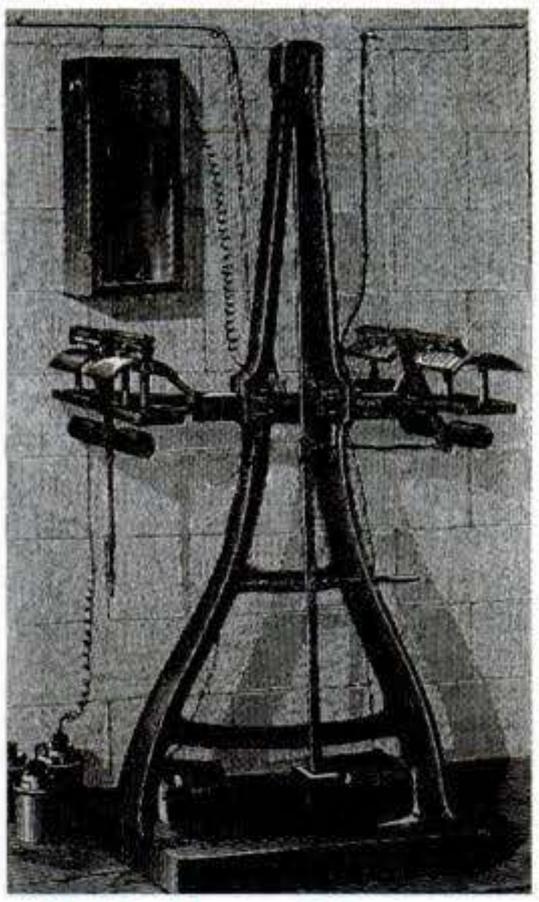


All-Out Warfare

50 YEARS AGO "YOU'LL NEVER see anything like that again," said Gen. George C. Kenney, head of the Strategic Air Command, about the thousands of planes that bombed Germany and Japan from advanced bases in World War II. Today, said Kenney, the military was concerned "with only one bomb, the atomic bomb." The bomb would be delivered by planes like the Boeing B-50 Superfortress (above) in a new type of long-distance, all-out warfare.—*August 1948*

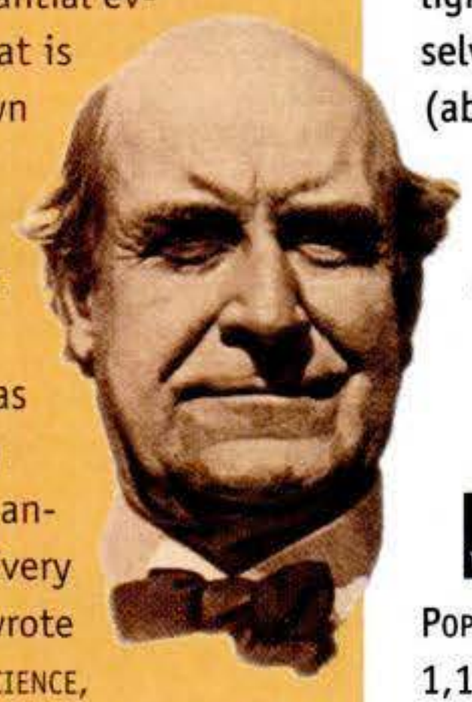


Nineteenth Century Fax

125 YEARS AGO "THE DISCOVERY that electricity could be transmitted instantaneously to great distances at once suggested the idea of employing it for signaling," we noted. Our editors traced the development of the telegraph through such scientists as André Marie Ampère and Alessandro Volta, up to Samuel Morse. And we detailed an 1862 invention by physicist Giovanni Caselli called an autographic telegraph, or pantelegraph (above left), "which produces at the receiving station a *fac-simile* of the original dispatch."—*August 1873*

Bryan on Evolution

75 YEARS AGO WRITING UNDER his own byline, William Jennings Bryan argued that science itself, as well as the Bible, condemns the theory of evolution. "Evolution," he said, offers only "circumstantial evidence that is overthrown by the indisputable fact that no species has ever been traced to another." "Every reader," wrote POPULAR SCIENCE, "whether he agrees with Bryan or not, should be interested in what he has to say."—*August 1923*



Three times an unsuccessful candidate for U.S. president, William Jennings Bryan was also the prosecuting attorney in the 1925 trial accusing John Scopes of teaching Darwinian theory. For full text of this article, go to **www.popsci.com**

Northern Lights

100 YEARS AGO THE AURORA borealis is no longer an object of superstitious dread and terror, said POPULAR SCIENCE. We stressed the relationship of the aurora to solar activity and Earth's magnetic and electric forces. Bands of light that fold on themselves, or become "draped" (above), are "the most beautiful of manifestations." The light of the aurora is not reflected or refracted, but luminous itself.—*August 1898*

Views of the aurora borealis will become more widespread as solar activity reaches "solar maximum," in 2000, according to the Space Environment Center in Boulder, Colorado. At the beginning of the 11-year solar cycle's last peak in 1989, the aurora could be seen as far south as Cancun, Mexico, says center forecaster Mike Schmeiser. For more on how the aurora borealis is created, see FYI next issue.

Monster Rock-Boring Moles

25 YEARS AGO INVESTIGATING A NEW TYPE of rock-boring mole (below; and, inset, at the end of boring cycle), POPULAR SCIENCE's Rob Gannon joined the crew of the 175-ton, 1,105-horsepower monster as it gouged out rock as quickly as 400 feet a day, some 70 feet under Rochester, New York. An efficient way to dig a tunnel, he reported.—*August 1973*

Gannon, whose first story in POPULAR SCIENCE appeared in 1959, continues to exercise his go-anywhere, do-anything type of participatory journalism on our pages. In his 112th and most recent feature story, Gannon stepped into an astronaut's shoes for simulation training at the Johnson Space Center in Houston ["A Walk on the Wild Side," May].

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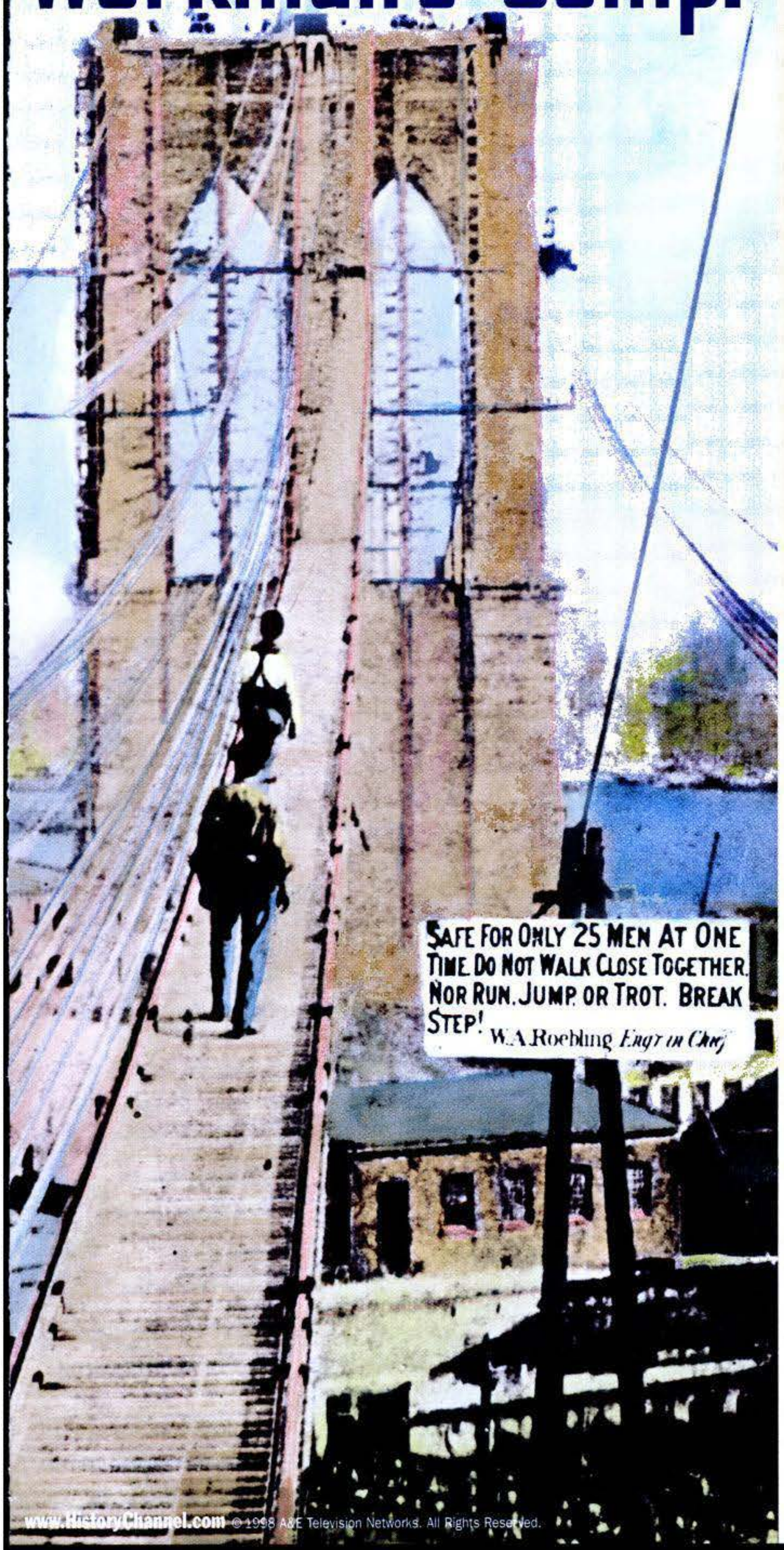

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